also can provide early seismic warning since earthquake preparation generates radio frequencies. It also acts as a proximity detector for ships & structures.

[The Amazing Ambient Power Module]
[Radio Waves Singal Earthquakes]
[Radio Earth: The Radio-Seismic Connection]
[US Patent # 4,628,299: Seismic Warning System Using RF Energy Monitor]

The Amazing Ambient Power Module

Parts List for the APM-2

Four 1N34 germanium diodes (Radio shack #276-1123) ~ Figure 1, X1, X2, X3, & X4
Two 0.2 mfd 50 V ceramic capacitors ~ Figure 1, C1 & C2
Two 100 mfd 50V electrolytic capacitors (Radio Shack #272-1016) ~ Figure 1, C3 & C4
Copper wire for antenna & ground connections

Introduction

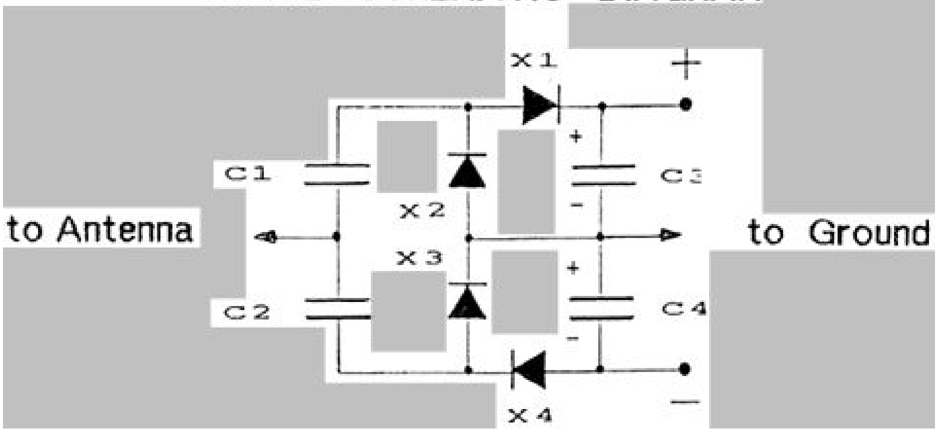
The Ambient Power Module (APM) is a simple electronic circuit which, when connected to antenna and earth ground, will deliver low voltage up to several milliwatts. The amount of voltage and power will be determined by local radio noise levels and antenna dimensions

Generally a long wire antenna about 100' long and elevated in a horizontal position about 30' above ground works best. A longer antenna may be required in some locations. Any type copper wire, insulated or not, may be used for the antenna. More details about the antenna and ground will be discussed further on.

The actual circuit consists of two oppositely polarized voltage doublers (Figure 1). The DC output of each doubler is connected in series with the other to maximize voltage without using transformers. Single voltage doublers were often found in older TV sets for converting 120 VAC to 240 VDC. In the TV circuit the operating frequency is 60 Hz.

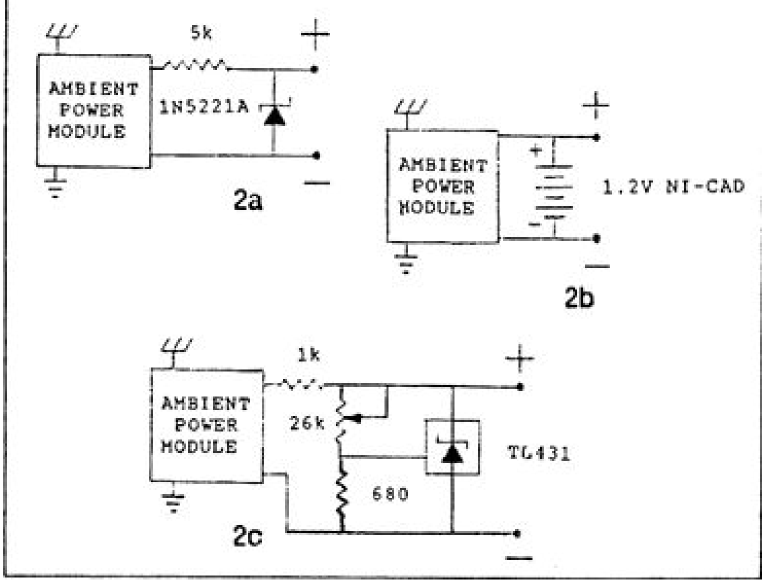
FIG. 1

APM-2 SCHEMATIC DIAGRAM



The APM operates at radio frequencies, receiving most of its power from below 1 MHz. The basic circuit may be combined with a variety of voltage regulation schemes, some of which are shown in Figure 2. Using the APM-2 to charge small NiCad batteries provides effective voltage regulation as well as convenient electrical storage. This is accomplished by connecting the APM-2 as shown in Figure 2B.

FIG. 2 (a, b & c)
VOLTAGE REGULATORS



Charging lead acid batteries is not practical because their internal leakage is too high for the APM to keep up with. Similarly, this system will not provide enough power for incandescent lights except in areas of very high radio noise.

It can be used to power small electronic devices with CMOS circuitry, like clocks and calculators. Smoke alarms and low voltage LEDs also can be powered by the APM.

Figure 3 is a characteristic APM power curve measured using various loads from 0-19 kOhm. This unit was operating from a 100' horizontal wire about 25' high in Sausalito CA. As can be seen from the plot, power drops rapidly as the load resistance decrease from 2 kOhm. This means that low voltage, high impedance devices, like digital clocks, calculators and smoke alarms are the most likely applications for this power source. Some applications are shown in Figures 4 through 7.

FIG. 3 AMP Power Envelope

Volts vs. Resistance

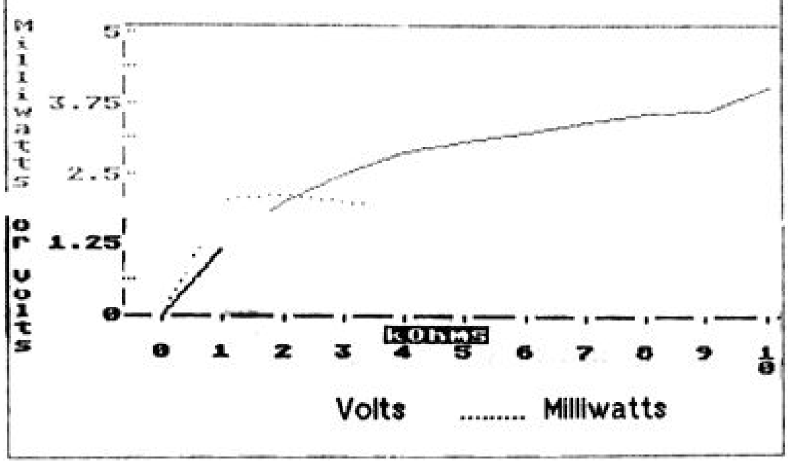


Figure 4 ~ A digital clock is shown powered by the APM-2. The 1.5 volt clock draws 28 microamps. Its position on the power envelope curve would be off the scale to the right and almost on the bottom line, dissipating only 42 microwatts.

FIG. 4 Clock powered by APM

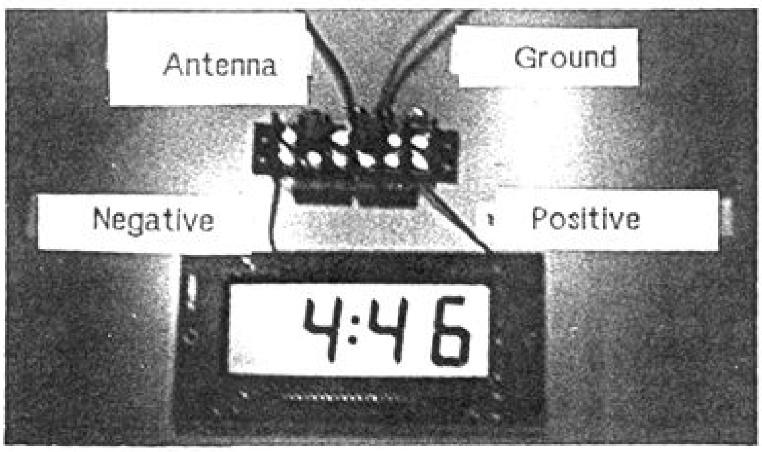


FIG. 5 APM charging a battery

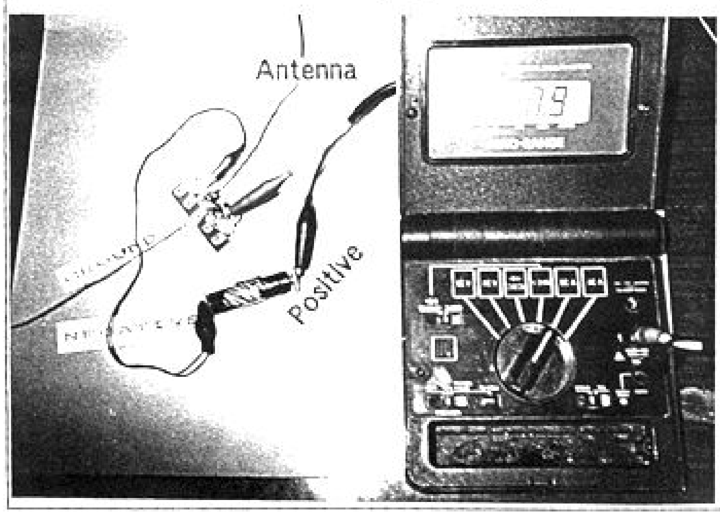


Figure 6 shows a clock which has the APM-2 built into it so it is only necessary to connect the antenna and ground wires directly to the clock. The antenna for this clock, which is a low frequency marine type, is shown in Figure 7.These antenna are expensive, not generally available, and usually don't work any better than the long wire mentioned above. But it may be necessary to use them in urban areas where space is limited and radio noise is high.

FIG. 6

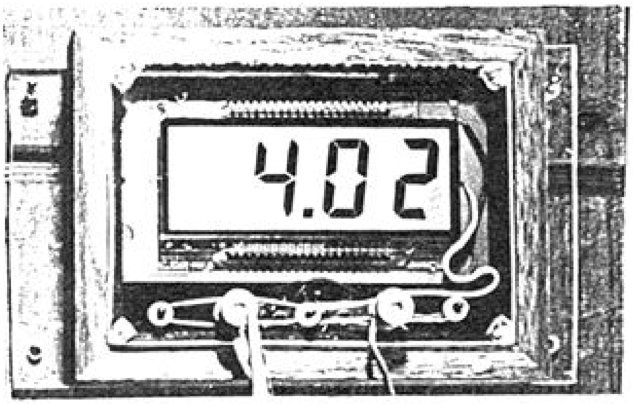
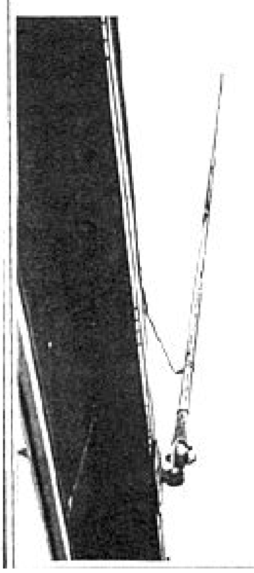


FIG. 7

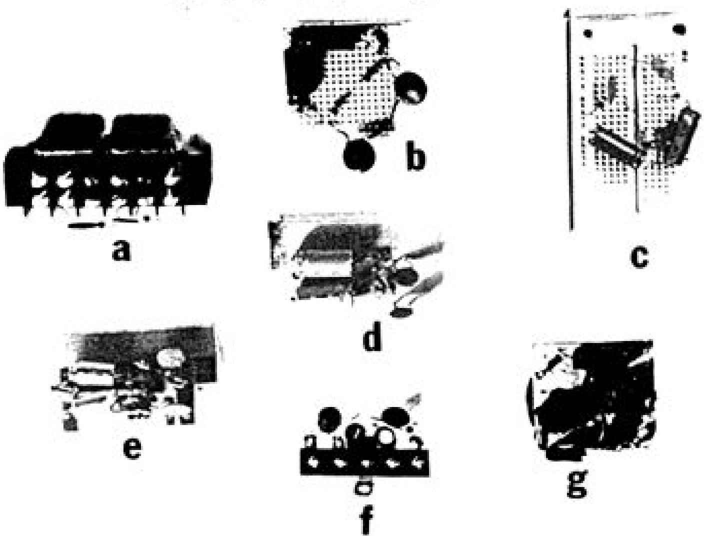


Building the Module

The builder has a choice of wiring techniques which may be used to construct the module. It may be hand wired onto a terminal strip, laid out on a bread board, experiment board, or printed circuit. Figure 8 shows some of the different ways of constructing the APM-2.

Figure 8A is constructed on a screw strip terminal; Figure 8B is constructed on a perforated breadboard; Figure 8C is built on a standard experiment board; Figures 8D, 8E, and 8F are all printed circuits; Figure 8F is made up on a solder strip terminal.

FIG. 8 a, b, c, d, e, f & g

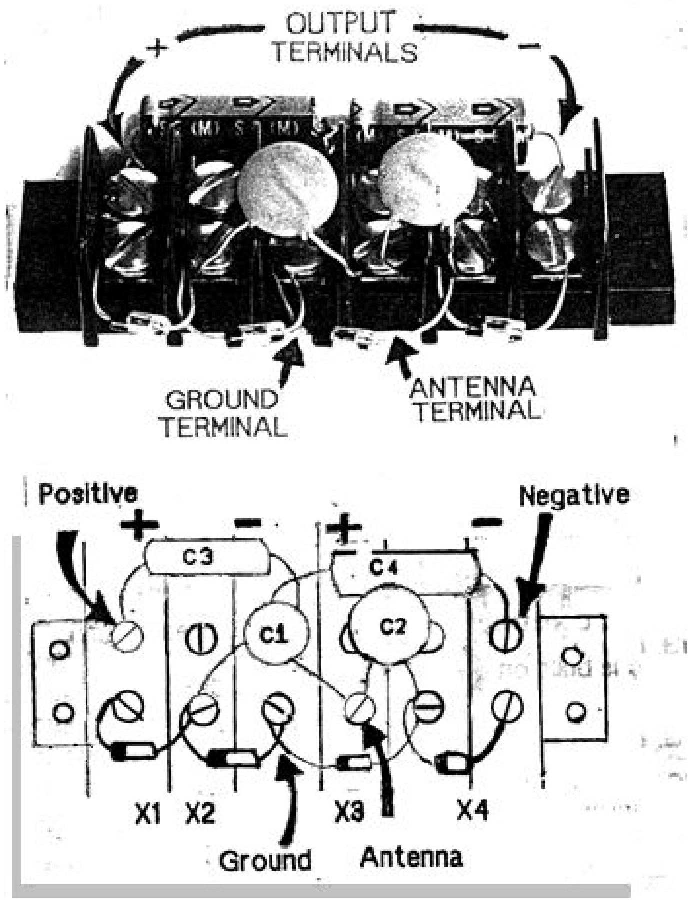


If you wish to make only one or two units, hand wiring will be most practical, either on a terminal strip or breadboard. Assembly on the terminal strip (Figure 8A) can be done easily and without

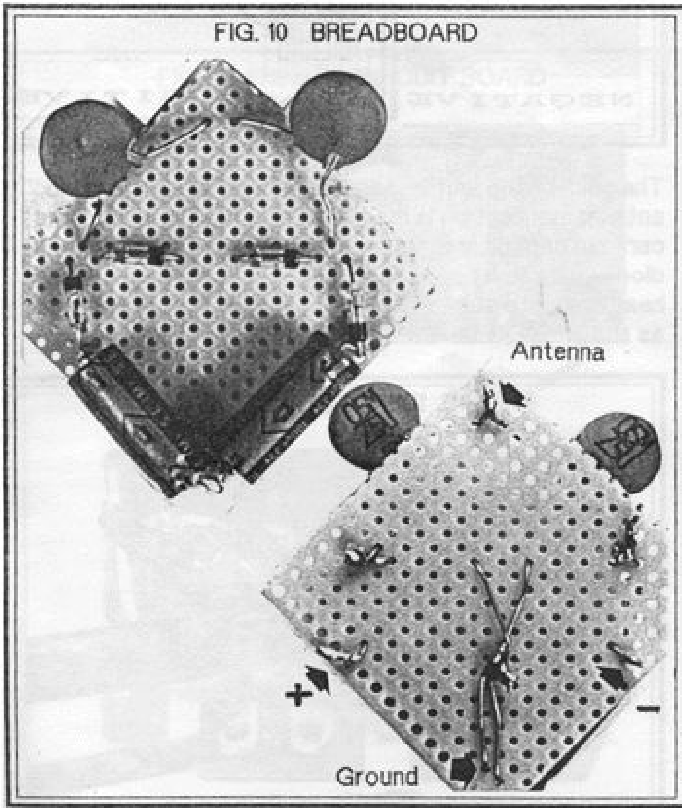
soldering. It is important to get the polarity correct on the electrolytic capacitor. The arrow printed on the side of the capacitor points to negative.

Figure 9 is a closer view of the terminal strip with an illustration of the components and how they are connected.

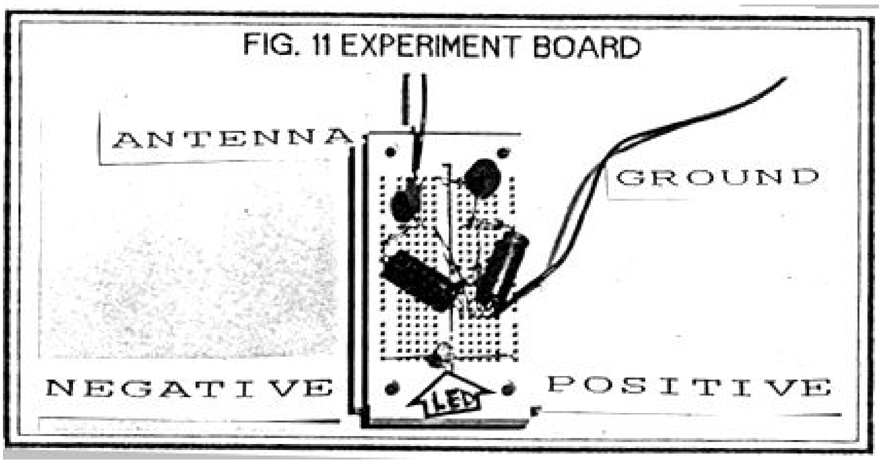
FIG. 9 TERMINAL STRIP



The breadboard unit is shown in Figure 10 with all components on one side and all connections on the other. All you need is a 2" x 2" piece of perforated breadboard (Radio Shack #276-1395) and the components on the parts list. Push component wires through the holes and twist them together on the other side. Just follow the pattern in the photo, making sure to observe the correct polarity on the electrolytic capacitors and the diodes. The ceramic capacitors may be inserted in either direction.



The experiment board unit is assembled by simply pushing the component leads into the board as shown in Figure 11. This unit is powering a small red LED indicated by the arrow.



The solder strip unit is made up on a five terminal strip. The antenna connection is made to the twisted ends of the ceramic capacitors. When soldering the leads of the 1N34 diodes, care must be taken to avoid overheating. Clip a heat sink onto the lead between the diode and the terminal as shown in Figure 12.

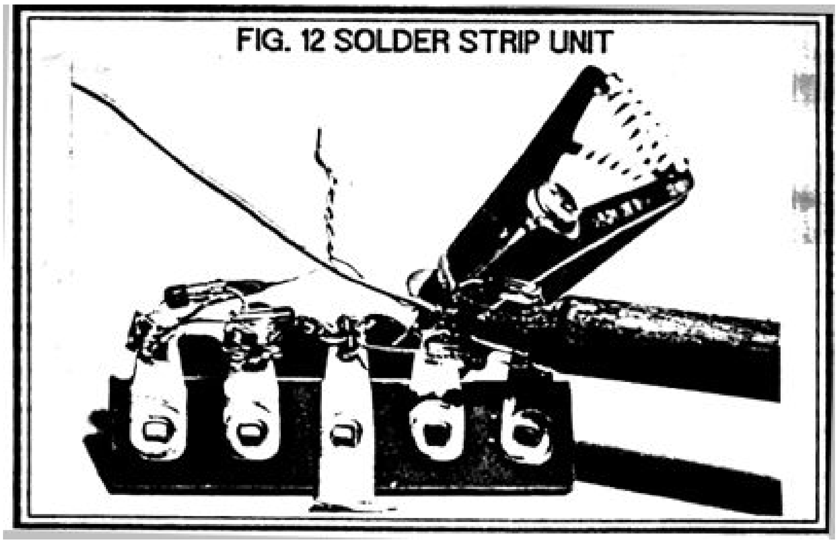


FIG. 12 SOLDER STRIP UNIT

It is beyond the scope of this pamphlet to show how to make printed circuits, but the layout of the board is provided in Figure 13.

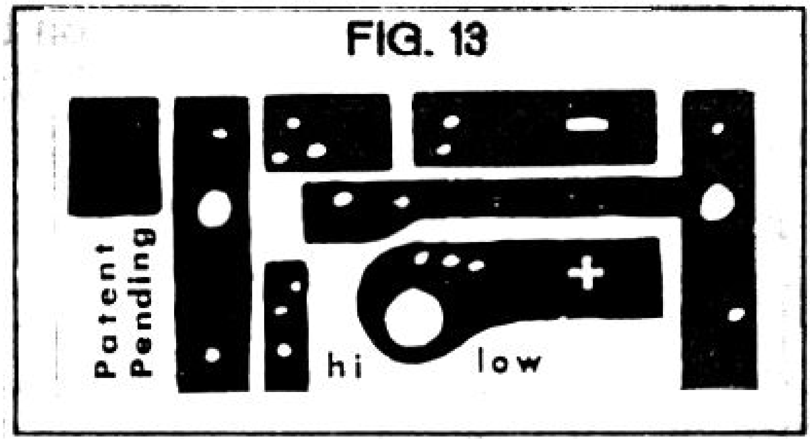
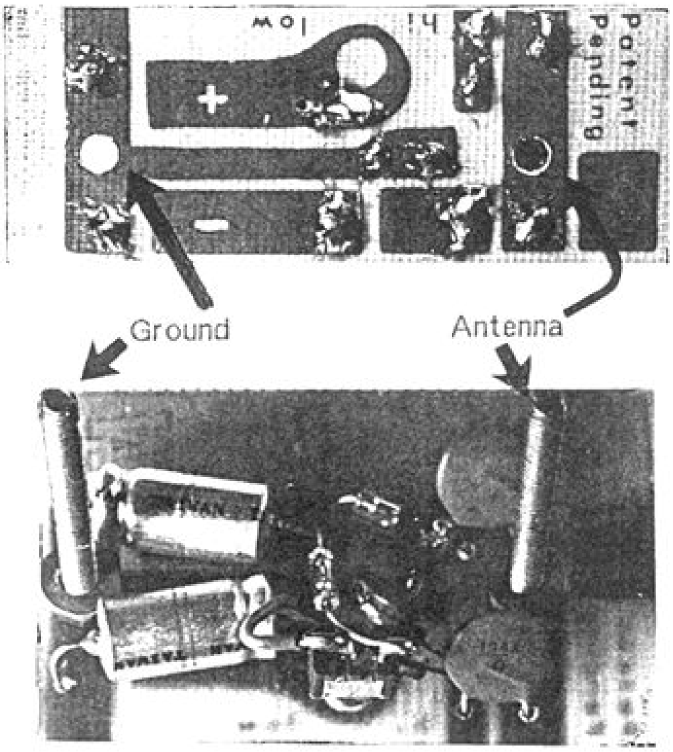


FIG. 13

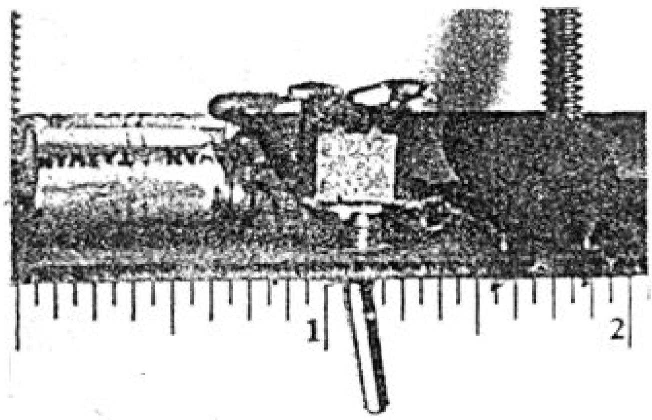
Figure 14 shows the front and back view of the completed printed circuit.

FIG. 14 PRINTED CIRCUIT BOARD



A small switch may be installed on the board to activate the zener regulator (Figure 15). This board was designed for use in clocks.

FIG. 15



Antenna Requirements

The antenna needs to be of sufficient size to supply the APM with enough RF current to cause conduction in the germanium diodes and charge the ground coupling capacitors. It has been found that a long horizontal wire works best. It will work better when raised higher. Usually 20-30 feet is required. Lower elevations will work, but a longer wire may be necessary.

In most location, possible supporting structures already exist. The wire may be stretched between the top of a building and some nearby tree or telephone pole. If live wires are present on the building or pole, care should be taken to keep your antenna and body well clear of these hazards.

To mount the wire, standard commercial insulators may be sued as well as homemade devices. Plastic pipe makes an excellent antenna insulator. Synthetic rope also works very well, and has the advantage of being secured simply by tying a knot. It is convenient to mount a pulley at some elevated point so the antenna wire may be pulled up to it using the rope which doubles as an insulator (Figure 16).

FIG. 16

Pulley & Wire

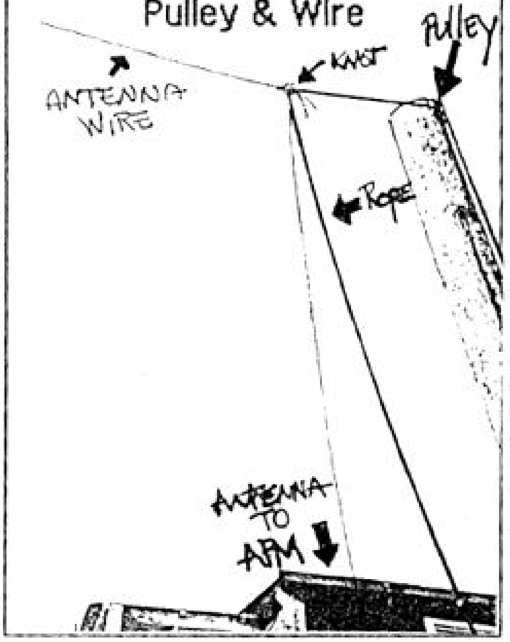
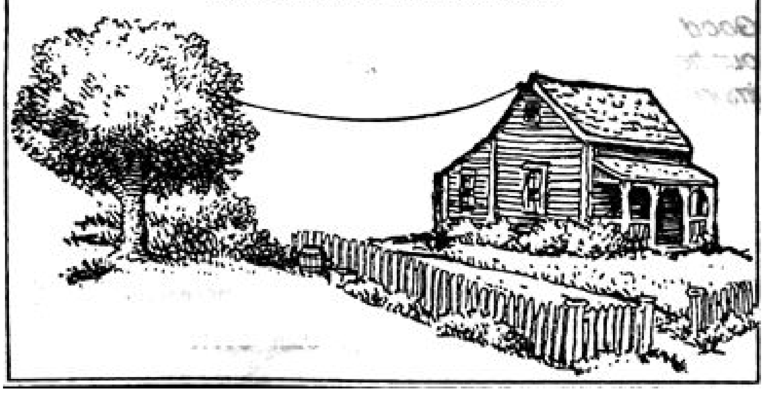


Figure 17 is an illustration of a horizontal wire antenna using a building and tree for supports.

FIG. 17

Horizontal Wire Installation



Grounding

Usually a good ground can be established by connecting a wire to the water or gas pipes of a building. Solder or screw the wire to the APM-2 ground terminal. In buildings with plastic pipes or joints, some other hookup must be used. A metal rod or pipe may be driven into the ground in a shady location where the earth usually is damper. Special copper coated steel rods are made for grounds which have the advantage of good bonding to copper wire. A ground of this type usually is found within the electrical system of most buildings.

Conduit is a convenient ground provided that the conduit is properly grounded. This may be checked with an ohmmeter by testing continuity between the conduit and system ground (ground rod). Just as with the antenna, keep the ground wire away form the hot wires. The APM's ground wire may pass through conduit with other wires but should only be installed by qualified personnel.

Grounding in extremely dry ground can be enhanced by burying some salts around the rod. The slats will increase the conductivity of the ground and also help retain water. More information on this subject may be found in an antenna handbook.

Good luck getting your Ambient Power Module working. It is our hope that experimenters will find new applications and improve the power capabilities of the APM.

Science News **[date unknown]**

Radio Waves Signal Earthquakes

From the bright flashes reported to appear in the sky during strong earthquakes to computer breakdowns during severe tremors, scientists have long suspected that seismic activity is associated with a variety of electrical effects. Recently researchers have been taking a careful look at this link, with an eye toward using it to predict earthquakes.

One such study is being conducted by Joseph Tate of Ambient Research in Sausalito, CA, and William Daily at Lawrence Livermore National Laboratory in Livermore, CA. With a system of radio wave monitors distributed along California's San Andreas fault, the researchers have recorded two kinds of changes in atmospheric radio waves prior to earthquakes that occurred between 1983 and 1986.

The most common change is a drop in the radio signals that normally pervade the air as a result of lightning and human sources such as car ignition systems and electric power grids. This reduction typically occurs one to six days before an earthquake and can last for many hours. For example, a magnitude 6.2 earthquake that shook Hollister CA in April 1984 was preceded six days earlier by a 24-hour drop in radio signals being monitored 30 miles from the quake's epicenter. Tate and Daily have found that the larger the earthquake, the longer the time between the radio wave depression and the quake.

Laboratory studies have shown that the electrical conductivity of rocks increases as they are stressed. Based on this and their electrical modeling of the ground, Tate and Daily think the increased conductivity of stressed rocks near the fault causes more radio waves to be absorbed by the ground rather than their traveling through the air. They also plan to test a possible link between radio wave drops and the emission of radon gas, which itself is thought to be a quake precursor. The radon may ionize the air, making it temporarily more absorptive than the detector antenna.

The researchers have also found, in addition to these drops, another prequake phenomenon in which short pulses of increased radio wave activity are emitted. For example, five days before the magnitude 6.5 earthquake hit palm Springs CA in July 1986, a station 15 miles from the epicenter detected a rise in radio signals. This sort of emission is consistent with laboratory work showing that cracking rocks release electromagnetic signals.

Tate says that in their first attempts at predicting earthquakes in 1984 and 1985, they did not miss a single event, so he his optimistic about using this technique for short-term forecasting of San Andreas quakes. "In three to five years", he says, "we should be able to issue [earthquake] warnings."

Whole Earth Review **(Fall 1990, pp. 101-104)**

Radio Earth: The Radio-Seismic Connection

by

Joe Tate

Since the earliest days of radio research, many people have thought of these invisible waves as artificial, an effect created solely by wizards in a laboratory. Later, in the 1930s, Karl Jansky discovered radio emissions coming from the Milky Way. Stars are now known to be giant transmitters, broadcasting a spectrum of electromagnetism from low-frequency noise to gamma rays. So much for the artificiality of radio.

Even in the 19th century, in the days of Tesla and Edison, radio noise caused by lightning was known to have recognizable propagation patterns. It was these patterns that Jansky was measuring when he discovered cosmic radio.

Tesla actually calculated the resonant frequency of the Earth, and proposed that electromagnetic waves of this frequency (6-8 Hz) should be generated by the planet from the action of lightning. These "Schumann resonances", as they came to be known, were finally detected in the 1960s.

Other strange radio emissions were noticed at about the same time, a time when many new radio observatories were starting operation at various places around the world. The observatories could each detect and record a wide range and volume of electromagnetic radiation (EMR). Before and during the great Chilean earthquake of 1960, unusual strong signals were received at six widely scattered radiotelescopes. The connection between these radio signals and the earthquake was eventually shown by James Warwick of the University of Colorado, who analyzed the observatories' separately recorded data (Figure 1) [Not shown]. Earthquakes generate radio waves! But how?

Twenty-two years later, after performing a series of laboratory experiments in which rocks were crushed in powerful presses and the resulting electromagnetic emissions were measured, Warwick's paper describing the phenomenon appeared in the April 1982 issue of the *Journal of Geophysical Research*.

In the meantime, other experimenters had recorded similar effects in Japan, France, the United States and the Soviet Union. Several studies of satellite data revealed marked increases in very-low-frequency (VLF) emissions from epicenter regions before and during major earthquakes. In Greece, researchers found that telluric currents (natural currents of electricity flowing in the Earth) fluctuated prior to earthquakes.

Ambient Power

In 1979, I was experimenting with methods of turning radio energy in the air into usable electric power. I developed a clock which drew its power from an antenna that was just a long piece of wire stretched out horizontally about 20 feet above the ground.

The power supply for the clock worked something like an old-style crystal radio, except that it did not have a tuning circuit. Because of this, the Crystal Clock (as I called it) was able to absorb a wide spectrum of radio noise from the antenna and yield electric power. The power supply was able to deliver much more current than was developed in a crystal radio, although its output was still just a few millivolts.

In the early 80s I demonstrated the clock to the late Frank Oppenheimer, then director of San Francisco's Exploratorium, where I worked in the exhibit repair shop. Oppenheimer suggested

recording the power supply's output over a long period of time to determine its dependability. After all, the device relied completely on whatever stray signals happened to be in the air.

Using an Atari computer which had been donated to themuseum, the oputput of the clock's power supply was measured continuously and recorded on floppy disk. This was done by feeding the unregulated voltage output direcly into the coputer's joystick port.

I began calling this power supply the "Ambient Power Module" (APM) because it extracted power from ambient background radio noise. This small circuit, when connected to antenna and ground, used the potential difference between air and ground to generate a small direct current continuously.

As we studied the recorded data, mild fluctuations were noted in a daily cycle. The patterns were consistent over long periods of time, though they differed in different locations. Aside form that, the APM looked like a very dependable source of power. Until the spring of 1984.

On April 24, 1984, a 6.0 magnitude earthquake struck about 90 miles from the APM recording station in Sausalito. Days later, while looking through the data, I noticed that the APM output dropped to less than half its normal value for several hours during the afternoon 6 days before the earthquake (Figure 2) [Not shown] this was very peculiar, because most of the APM's power came from broadcast signals, and broadcasting stations hadn't done anything different that afternoon. Apparently something had temporarily depressed the propagation of radio waves. At high frequencies, such effects can be caused by atmospheric conditions. But the lower frequencies involved here are hardly affected, particularly not the signals from the nearest stations, which account for most of the power received. It was tempting to think this strange radio depression might somehow have been a precursor to the earthquake.

Several smaller quakes had occurred in the area during the year before. Perhaps these also were preceded by similar radio anomalies. Looking back through the accumulated data on the APM's power output, indeed, smaller, less obvious radio depressions were found to occur prior to the lesser earthquakes.

I called the US Geologic Survey (USGS) office and told them about these radio events. I learned from them that ham operators in the area had also reported radio noises accompanying earthquakes, but no one had recorded them. Jack Everenden, with whom I was speaking, asked for copies of my data, which I sent.

Two weeks later, William Daily of Lawrence Livermore Labs called, asking if I would like to work with him gathering earthquake radio noise data under a grant from the USGS.

Radio Earth

For the next three years we deployed monitoring/recording devices along the San Andreas fault, from San Francisco to San Diego. The units were battery-powered paper-chart recorders which could hold one month's worth of data. They recorded radio noise levels in three adjacent bands: 0.2-1, 1-10 and 10-100 kHz. In addition we continued using the APM recorders in two locations, Sausalito and San Mateo.

During this period, some 46 earthquakes 4.0 and above occurred within 120 miles of our stations. Of these, 32 quakes were preceded by a radio anomaly. Only five quakes were not preceded by radio precursors. These were also ten false positives (radio events with no quakes following). These may have been caused by earthquake prepartion forces which failed to mature. Either way, our score was about 70%.

The results of our study were published in October 1989, just as the Loma Prieta Earthquake struck northern California.

By this time we had dismantled our network of recording stations. However, one of the original APM recorders was still running at my lab in Sausalito. This instrument recorded the largest radio depression I have ever seen, about 60 days prior to the October 17 shocks (Figure 3) [Not shown]. I had reported that event to Galilee Harbor's board of directors, but no action was taken.

In studying several smaller earthquakes from 1985-1987, it appeared that the larger the earthquake, the larger and sooner the precursors appeared. The 6.0 earthquake of April 24, 1984 was preceded by a radio depression 6 days before the shock. The Loma Prieta Earthquake of about 7.0 magnitude was preceded by a much greater radio depression 60 days before. A 7.0 magnitude quake is 10 times greater than a 6.0. The 60-day precursor time for the 7.0 earthquake was 10 times the precursor time for the 6.0 earthquake. More data is needed to clarify this relationship.

Warrick's lab showed that fracturing rocks generate radio waves: when Westerly granite was crushed in a shielded space, a receiving antenna detected broadband signals ranging from 500 kHz to 30 MHz. Most of the energy was concentrated at the lower frequencies.

Other experimenters measured changes in the electrical resistance of rocks under pressure. During the late 1970s, William Brace of MIT compressed various rocks in a powerful press while recording their resistance. He found that as rocks approach fracture pressure, they become much more electrically conductive. A related experiment by William Daily at Lawrence Livermore Lab subjected rocks to evenly distributed pressure while their electrical resistance was measured. Under uniform pressure, the rocks did not show the changes in resistance produced in Brace's press. That suggested it was stress caused by force being applied unevenly which caused the observed changes in resistivity.

Although Warwick's experiment proved rocks can emit radio waves during crushing, calculations showed that any such waves generated far underground would be absorbed by the earth, never reaching the surface with enough energy to be detected in the atmosphere. In addition, this effect could not explain the decrease of ambient radio energy observed by us and others.

Takeo Yoshino, of the University of Electro-Communications in Tokyo, has proposed that "resistance slots" form along a fault line due to effects similar to those demonstrated by Brace. Yoshino argues that if ground resistance becomes high enough in these slots, then radio waves coming from below will pass through them, rather than being absorbed, and enter the atmosphere. It would also mean atmospheric radio energy could pass into the earth through these slots. This could create interesting resonant effects.

Does ground resistance actually reach the levels needed to sustain such an effect? It is known that ground water enhances ground conductivity. However, C.B. Raleigh of the USGS has calculated that enough heat can be produced by friction during the earthquake preparation process to boil the ground water out of a rupture zone. Perhaps dehydration could combine with stress-induced fluctuations in rock resistance to produce slots of heightened electrical resistance in the earth's crust.

Based on this idea, it is my belief that the radio depressions and emissions recorded by us and others are the result of fluctuations in ground radio absorption.

Radio waves moving through the atmosphere are always being partly absorbed into the ground. The absorption rate varies from place to place, based on the ground's conductance and the distribution of rocks and sediments. If anything alters this equilibrium, the radio fields in the atmosphere should also be affected. For instance, more ground absorption should result in a lower intensity in the atmosphere. A loss of absorption would produce increased intensity in the atmosphere. Seismic radio events may be due to this effect.

As a model for explaining the observed radio anomalies, this has appeal, since it can account for both radio emissions and depressions. It could also explain the changes in telluric currents recorded

in Greece prior to earthquakes. As ground conductance changes, currents flowing through the Earth may be diverted to channels and zones of greater conductance.

As more data is gathered, we'll understand more about these phenomena. In the meantime, though, we're on a slow learning curve, limited by the frequency of large earthquakes. There is really no way to speed up this process, and perhaps we don't actually want to.

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US Patent # 4,628,299

Seismic Warning System Using RF Energy Monitor

Joe Tate, et al.

Abstract -- The ambient broadband radio frequency field strength from broadcast stations is monitored (Figure 4) by periodic sampling (50, 52). A warning indication is provided if the field strength drops significantly. Drops in such field strength have been correlated empirically with the occurrence of seismic activity, usually several days later. Thus the indication serves as an early warning of an impending earthquake. In one preferred embodiment, a broadband, horizontal, very long monopole antenna (40) was connected to a rectifying and smoothing circuit (Figure 3) to provide a dc output proportional to the ambient rf field. This voltage is digitized (50), and using a suitably programmed computer (52), the digital version of the field strength signal is sampled once per minute (78). A cumulative or running average of the minute samples is calculated (80) and held. Once per hour the latest running average is stored (84) and a standard deviation (SD) of the last 24 hourly stored running averages is calculated (88). If the SD exceeds a predetermined value, 0.3 in one embodiment, an alarm is triggered (92). The use of the SD eliminates the effect of day-to-day changes in the amounts of the variations of the ambient field strength, due to changes in tides and other factors. Once per day the samples are written (96) to a permanent storage file and a continuous plot of the field strength is also made (14). Preferably the alarm is triggered only if another detector also provides an indication (FIG. 6), thereby to eliminate the effect of machine error.

Inventors: Tate; Joseph B. (Sausalito, CA); Brown; David E. (Mill Valley, CA)
Assignee: Pressman; David (San Francisco, CA)
Appl. No.: 695632; Filed: January 28, 1985
Current U.S. Class: 340/540; 324/323; 324/344; 340/600; 340/690; Intern'l Class: G08B 021/00
Field of Search: 340/540,600,690

References Cited
U.S. Patent Documents

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4,364,033, Dec., 1982, Tsay 340/540.

Description

Background: Field of Invention

This invention relates to the prediction of the fugure occurrence of seismic activity, particularly to the advance notification of earthquakes through the monitoring of ambient radio frequency (rf) energy.

Background: Description of Prior Art

Heretofore, insofar as we are aware, seismology, the science of earthquakes, has not been able to make any near-term predictions of earthquakes.

While scientists have known that certain animals may have had some sort of advance knowledge of quakes, due to the fact that they exhibited peculiar behavior before quakes, and not at other times, this behavior has not been consistent and reliable enough to be of practical use.

Also, while scientists have also been able to predict thunderstorms in advance by monitoring the ambient electrostatic field (see, e.g., US Pat. No. 3,611,365 to Husbyorg and Scuka, 1968; 3,790,884 to Kohl, 1974; and 4,095,221 to Slocum, 1978), they have not been aware of any corresponding system for earthquake prediction.

Scientists have been able actually to detect earthquakes during their occurrence by monitoring air pressure variations (e.g., as described in US. Pat. No. 4,126,203 to Miller, 1978) and by monitoring the earth's physical movement by seismographs but, again, science has not been aware of any system for short-term advance detection or prediction of quakes.

Due to the devastating effects of quakes to property, life, and limb, public and governmental authorities would derive great benefit from any system which could provide short-time advance notification of great earthquakes. As it is now, except for aftershocks, which seismologists know will occur after any large quake, all great and small quakes occur without warning. Because people in the vicinity of such quakes are unprepared, they often are in places of great vulnerability, such as beside or inside collapsible buildings, so that severe and human injury usually occurs during a quake. Also, property itself is left vulnerable, e.g., by leaving automobiles in or near collapsible buildings, leaving gas and electricity connected such that disruption of these facilities causes fires, and leaving other valuable property in vulnerable areas. If advance notification of a large quake could be provided to the public and civil authorities, people and valuable property could be evacuated and protected, thereby preventing deaths, injuries, and greatly reducing property damage. Further, advance notification of quakes would eliminate the severe psychological trauma which often affects large segments of the populace due to the surprise occurrence of quakes.

Objects & Advantages

Accordingly several objects and advantages of the invention are to provide a reliable and effective method of earthquake prediction, to provide a method of preventing death, injuries, and reducing property damage in earthquakes, and to provide a method of reducing the psychological trauma which often accompanies quakes due to their surprise occurrence. Additional objects are to provide such a system which is easy to use, economical, reliable, and portable. Further objects will become apparent from a consideration of the ensuing description, taken in conjunction with the accompanying drawings.

Background: Theory of Invention

The following is a discussion of the background theory of the invention. While we believe it to be technically accurate, we do not wish to be limited by this theory since the operability of the invention has been empirically verified, as will be apparent from the later discussion.

We have recently worked work with the reception and utilization of broadband radio-frequency reception, e.g., for low-power utilization applications, as discussed in the copending application Ser. No. 06/539,223 of Joseph B. Tate, filed Oct. 6, 1983. While doing this work, we have noted that the antenna's output voltage fluctuated with time due to certain, known causes.

First, we noted that the higher we placed an antenna above the ground, the the greater the output signal it provided. We have observed this by raising the physical height of an antenna and observing an increase in power output, and also by observing variations in the output of a fixed antenna near a body of ocean water as a function of the tides: the antenna's output was greatest at low tide and lowest at high tide. We believe that the change in water level, which serves as a ground plane, effectively lowers or raises the height of the antenna above the ground.

We also noted that the antenna's output was affected by solar flares to a limited extent; these caused the antenna to produce a higher output voltage during their occurrence. We believe this phenomena is caused by an increase in the level of ambient ionization due to the flares.

Further, we noted that the antenna's output dropped at certain irregular times; at first we would not attribute any cause to these drops. However investigation enabled us to correlate these drops with the subsequent occurrence of seismic activity. We found that the magnitude of the drop was proportional to the size of the subsequent earthquake.

Certain phenomena have been discovered to precede earthquakes. These include an anomalous uplift of the ground, changes in the electrical conductivity of rock, changes in the isotopic composition of deep well water, changes in the nature of small earthquake activity (e.g., bunching of small foreshocks), anomalous ground tilt or strain changes, changes in physical properties, such as porosity, electrical conductivity, and elastic velocity in the hypocentral region. *Earthquake, McGraw-Hill Encyclopedia of Science And Technology*, 1960; *Earth* by F. Press, W. H. Freeman & Co., 1974.

Phenomena associated with rocks have attracted much recent attention. Wm. Brace of the Mass. Inst. of Technology has found that when rocks were squeezed or compressed, just before they fractured, they tended to develop hairline cracks, swell or dilate (dilatancy), become more porous and electrically conductive, and transmitted high frequency seismic-like waves more slowly. Two of Brace's former students, Amos Nur of Stanford University and Christopher Scholz of Lamont-Doherty furthered Brace's work, connecting the dilatancy theory with seismic P-wave velocity shifts and rock resistivity changes as a precursor for earthquakes. See. e.g., Brace, Orange, and Madden, *J. Geophys. Res.*, 70(22), 5669, 1965; A. Nur, *Bull. Seis. Soc. of Amer.*, V 62, Nr. 5, pp. 1217-1222, 1972 Oct.; *Earthquake* by B. Walker, Time-Life Books, 1982.

Based upon the above background, we have developed a theory as to the cause of this drop in antenna output as a precursor or predictor of earthquakes. We believe that before a quake occurs, the pressure within underground rock bodies temporarily increases greatly, causing the rocks to dilate and become conductive, in accordance with the works of Brace, Nur, and Scholz. This increase in conductivity effectively raises the ground plane, thereby causing the antenna's output to decrease temporarily.

Thus before the occurrence of a quake, the underground pressure increases greatly temporarily, causing underground rock bodies to swell and become more conductive, thereby raising the ground plane, which in turn causes the voltaic output of nearby antennas to drop.

We accordingly constructed an apparatus to automatically monitor antenna output and provide a suitable indication if the output level dropped significantly. The indication was calibrated empirically after much experimentation so as to filter out the effects of solar- and tide-caused variations. We did this by arranging the apparatus so that an output indication was provided only if the antenna output dropped a predetermined degree beyond its average level; we utilized statistical filtering techniques to accomplish this.

Drawings

Figure 1 shows the front panel of a Seismic Early Warning (SEW) apparatus according to the invention.

Figure 2 is a plot of voltage (representing ambient rf level) v. time as measured by the apparatus of Figure 1.

Figure 3 is a schematic diagram of an ambient power module circuit (used in the SEW apparatus) for producing a DC output voltage proportional to the ambient rf energy

Figure 4 is a block diagram of a computer in the apparatus of Figure 1.

Figure 5 is a flowchart which depicts the operation of the SEW system.

Figure 6 is a flowchart which depicts the operation of an optional alarm trigger system useable with the SEW apparatus.

Figure 1: Seismic Early Warning Apparatus

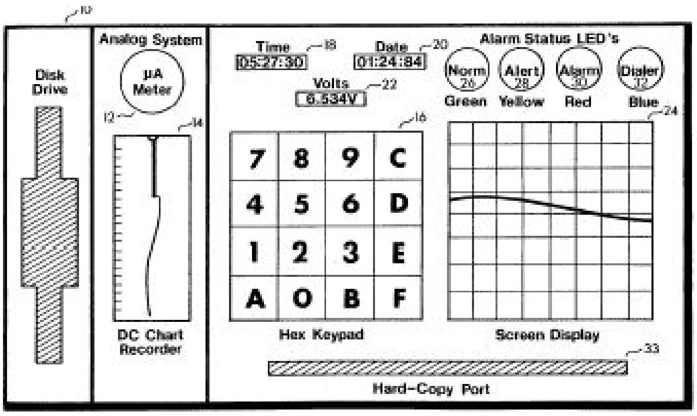


FIG 1

In accordance with the invention, a seismic early warning apparatus is provided as shown in FIG. 1. The apparatus consists of a housing containing a general purpose computer (not shown), a disc drive 10, an analog system comprising a microampere meter 12 arranged to monitor direct current (which is proportional to the ambient rf energy), and a direct current strip chart recorder 14 arranged to provide a continuous indication of the current antenna output, which will be called the ambient power level. A hexidecimal keypad 16 is provided to enter data, such as time, for entering programs and changes and for operating the system according to preset codes. The time, date, and voltaic level of the antenna's output are continuously indicated by digital readouts 18, 20, and 22, respectively. A screen display 24 is provided to display graphic and alphanumeric information of the current status of the apparatus and previous data records.

Lastly the apparatus includes four status-indicating lamps, which preferably are LEDs (light-emitting diodes) as follows: A green LED 26 indicates that the system is on and functioning normally. A yellow LED 28 indicates that the system has detected an event, namely the occurrence of a drop in ambient power below the preset level, which would be the prediction of an impending earthquake. A red LED 30 is provided as backup confirmation of the occurrence of the event; LED 30 is illuminated when a duplicate receiving system also detects an event. A blue LED 32 indicates initiation of operation of an automatic telephone dialer within the system, which has been preprogrammed to dial a predetermined number and provide a warning in the event of an occurrence of an alarm condition. Lastly the apparatus includes a hard copy output port 33 for providing printed graphic and numeric outputs of all system data.

Figure 2: Ambient RF Level vs Time Before Quake

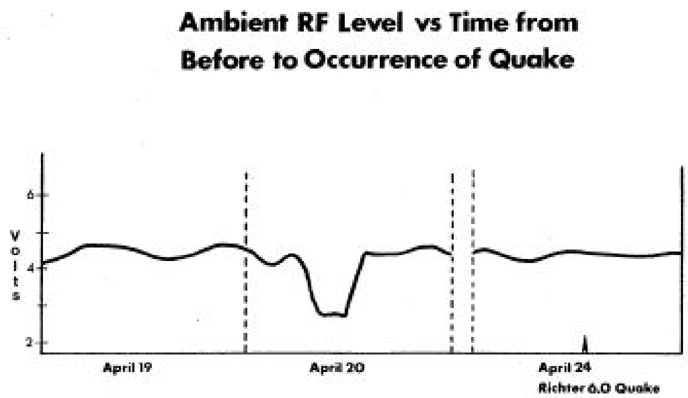


FIG 2

Figure 2 illustrates a reproduction of an actual plot of a voltage as a function of time, which voltage was proportional to the ambient RF (radio frequency) level, from the period from before to after a

relatively large earthquake. This plot, which is typical of many we have observed before a quake, was made by deriving the voltage with a 30-meter, long-wire monopole antenna (not shown) which was mounted horizontally and which extended over San Francisco (Richardson) Bay easterly from Sausalito, California, 9 meters above sea level. The antenna thus intercepted and converted to an RF voltage the ambient RF energy, mainly from local (San Francisco area) AM radio stations. We rectified and filtered the output of the antenna using one-half of the circuit of FIG. 3 (described below) to provide a DC voltage which was plotted on a conventional ink-on-paper plotter. Note that on the section of the chart for Apr. 19 (1984), which begins at time 0:00 (midnight) and ends at 24:00, the voltage or ambient RF power level at the antenna increased and fell and then increased slightly in the 24-hour period. This wavelike variation typically occurs on a daily basis and is caused by tides: the peaks occurring at low tide when the effective ground plane provided by the water drops and the troughs occurring at high tide when the ground plane rises.

On Apr. 20, from about 8:00 to about 12:00, a sharp and constant-level dip in the ambient rf power occurred, as indicated. The magnitude of this pronounced dip is far greater than the normal tide-caused variations, as is its beginning and ending slope.

Thereafter, from Apr. 20 to Apr. 23, the plot (not shown) continued unremarkably, albeit with a slight variation from normal.

The same occurred on Apr. 24, with the plot actually being generally similar to a normal day. However at 13:15 on Apr. 24, as indicated, a large, Richter magnitude 6.0 quake occurred near Hollister, Calif., about 340 km away from the antenna. No change in the plot occurred at this time.

Correlation of this quake with the plot's marked dip of Apr. 20 was made by the repeated observation of dozens of similar dips and subsequent quakes. Pronounced dips were always followed by a quake several days later. Thus we have empirically established causal and theoretical connections between pronounced dips of the type shown and the occurrence of subsequent seismic activity.

Figure 3: Ambient Power Module

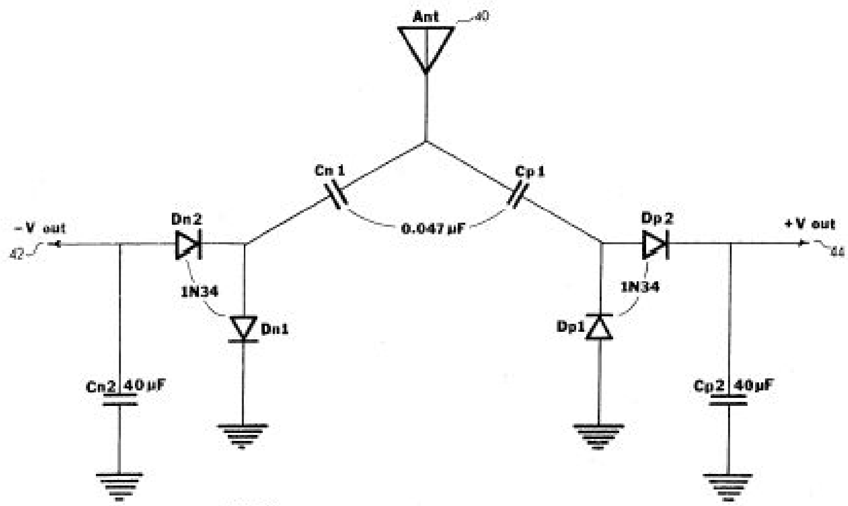


FIG 3

The circuit of Figure 3 is used to convert the ambient RF energy to a direct voltage which can be used and handled by data processing equipment. Designated an ambient power module (APM), it is connected to an antenna 40, preferably a broadband monopole antenna of the type described in the preceeding section. The distal end of the antenna is free and its proximal end is connected to the circuit via two capacitors Cp1 and Cn1, each being in series with the signal line for coupling and each having a value of 0.047 microfarad. Taking the left or negative side of the circuit first, it

comprises two rectifiers (diodes) Dn1 and Dn2 (1N34 type) and a filter capacitor Cn2 (40 microfarads). Rectifier Dn1 is connected in parallel to the signal path and rectifier Dn2 is connected in series, in the well known voltage multiplier arrangement. Capacitor Cn2 is connected in parallel across the output of the APM to smooth the rectified output. The right or positive side of the circuit is similar, except for the polarity of the diodes.

In operation, an RF voltage is developed across antenna 40; this voltage is voltage multiplied by the two rectifiers on each side of the circuit. The resultant direct voltages are smoothed or filtered by capacitors Cn1 and Cp2 and are supplied to output terminals 42 and 44. A positive version of this direct voltage is plotted in Figure 2, as described above.

Figure 4: Block Diagram of Computer

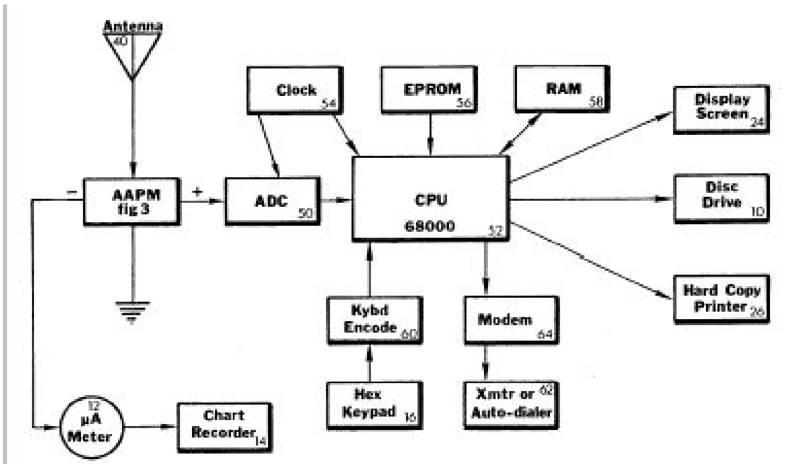


FIG 4

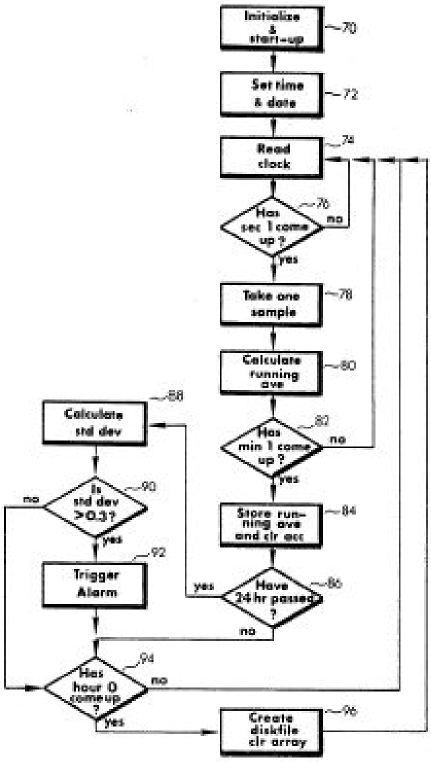
A computer for performing the monitoring and alarm functions of the invention and which is provided within the apparatus of Figure 1 is shown in Figure 4. The computer receives the positive voltage from the APM (Figure 3) and processes this, providing an alarm if the voltage dips a predetermined amount from its recent average value.
The computer comprises an analog to digital converter (ADC) 50 which is arranged to convert the positive DC voltage from the AAPM to digital form, preferably in the form of a parallel signal at the output of ADC 50. The digitized voltage from ADC 50 is supplied to a central processing unit 52, which is a type 68000 microprocessor or computer on a chip. CPU 52 and ADC 50 are clocked by a clock 54 in conventional fashion.

CPU 52 operates on instructions from a program contained in an electrically programmed read only memory (EPROM), the program being listed later. CPU 52 temporarily stores data in a read and write memory (RAM) 58. CPU 52 also supplies output data to display screen 24, disc drive 10, and hard-copy printer 26', each of which was already described in conjunction with Figure 1.

CPU 52 can receive input data manually from hexidecimal keypad 16 (see FIG. 1) via a keyboard encoder 60.
CPU 52 can supply an alarm output to a radio transmitter or automatic telephone dialer 62 via a modem (modulator-demodulator) 64 for connecting the CPU to a phone (not shown).

As also indicated in Figure 4, the negative output of the AAPM of Figure 3 is connected to ammeter 12 and chart recorder 14.

Figure 5: Flowchart of Seismic Early Warning System



In operation, the system of Figure 4 operates under control of the program in EPROM 56 in accordance with the flowchart of Figure 5 as follows:

Startup: Blocks 70 and 72: An initialization and start-up sequence is first initiated when the machine is turned on, as indicated by block 70; this sets all registers and counters to zero. The time and data are then set manually (using EPROM 56), as indicated by block 72.

Clock Reading: Blocks 74 and 76: Next, under automatic program control, the machine reads the elapsed time on its clock display register, as indicated by block 74. If the "seconds" register does not indicate the number one (#1), the machine continues to read the clock, as indicated by the "no" output of decision block 76.

Minute Sample: Block 78: When second #1 appears, as it will once per minute, the decision in block 76 will be "yes", so that the machine will take one sample of the rectified, smoothed, and digitized version of the antenna's output, i.e., the output of ADC 50 of Figure 4, as indicated in block 78. This sample will be taken once per minute, i.e., whenever second #1 is displayed.

Running Average: Block 80: Next, as indicated by block 80, a running average of the samples taken in block 78 is calculated. This is done by accumulating the samples to keep a running total of their values, counting the number of samples accumulated, and dividing the running total by the latest number of samples each time a new sample is taken.

Store Hourly Average: Blocks 82 and 84: Next, as indicated in block 82, a test is made to see if the time display register indicates that minute number one (#1) has come up. If not, the decision is "no" and the clock is read again (block 74). If the decision is "yes", as it will be once per hour, the running average in the accumulator will be stored (block 84) and the accumulator will be cleared or reset to zero.

One Day Test: Block 86 ("No" decision) and Block 94: Next the machine makes a test to see if 24 hours have passed. If not, the machine will not be able to make any valid statistical determinations. Thus it must run at least 24 hours before being operative. Assuming the decision in block 86 is

negative (24 hours have not yet elapsed) another test is made (block 94) to see if hour zero is indicated, which will occur once per day. If hour zero is not indicated, (decision in block 94 is negative), the clock will be read again (block 74) in the usual loop.

Calculate SD: Block 86 ("Yes") and Block 88: If a full day has elapsed, so that valid statistics can be calculated ("yes" from block 86), the standard deviation (SD) of the last 24 hourly averages is calculated, as indicated in block 88. This is done once per hour. The calculation is made using the usual SD formula

SDDEV=SQR([sum(x-X).sup.2]/n)

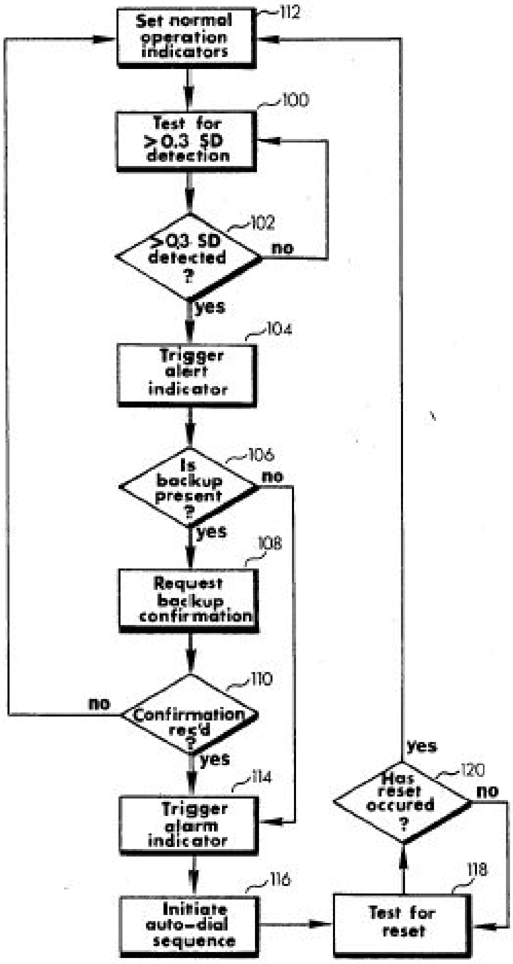
where SDDEV=SD; SQR=the square root; sum=the sum of; x=the individual hourly averages; X=the mean of the hourly averages; and n=the number of individual hourly averages. Essentially the SD is calculated by taking the mean of all of the hourly averages, taking the difference or deviation of each hourly average from the mean, squaring each deviation, taking the mean of the squared deviations, and then taking the square root of the mean of the squared deviations.

Evaluate SD: Block 90: The SD is then evaluated to see if it is greater than 0.3. This value has been empirically determined to be the level at which the present apparatus will provide a reasonably positive indication that an earthquake will occur, while neglecting the effects of non-seismic-caused variations. If the SD is less than 0.3, (a "no" output from block 90), this indicates that the last hourly average was not greatly different from the average of the last 24 hourly samples, so that no alarm need be indicated. I.e., the antenna's output did not drop significantly to indicate an impending earthquake. Thereupon the program moves to block 94, where a test is made for the existence of hour zero, as described. If, however the SD exceeds 0.3 ("yes" output of block 90), this indicates that the antenna's output has dropped significantly so as to affect the last hourly average, thereby to indicate an impending earthquake.

Alarm: Block 92: In response to the Yes output of block 92, an alarm is triggered (block 94). The alarm may be a bell, the dialing of a telephone to a location where personnel are present if the apparatus is placed at a remote or non-manned location, or the initiation of the further program of the Flowchart of Figure 6, the alarm trigger sequence. To eliminate the possibility of equipment failure and to provide confirmation from another apparatus at another location, we prefer to provide an alarm only upon confirmation from another apparatus, as discussed in the description of Figure 6 below.

Make Record: Block 94 ("Yes") and Block 96: If hour zero is being displayed when the operation of block 94 is performed, which occurs once per day at midnight, the operation of block 96 will be performed, i.e., the data in the registers will be stored to disc to create a permanent record and the registers will be cleared to create new data for the next day. However the previous 24 hourly averages are still stored at all times so that a valid SD can be calculated and tested every hour. After the operation of block 96, the clock is read again in accordance with the regular program (block 74).

Figure 6: Alarm Trigger Flowchart



The sequence of Figure 6 is performed when the alarm is triggered in block 92 of Figure 5 as an optional, but preferred backup confirmation of an impending earthquake. The operations in the backup confirmation system will be described briefly.

Beginning with blocks 100 and 102, the system is continually tested (hourly) for the occurrence of a SD of the hourly averages of greater than 0.3. If the SD is greater than 0.3, the alert indicator (28 of Figure 1) is triggered (block 104) and the program initiates a test (block 106) to see if a backup apparatus (not shown) is present. If so (yes output of block 106) the backup apparatus is also checked (blocks 108 and 110). If the backup does not indicate an excess SD, the indicators are reset to normal (block 112), but if backup confirmation is received, the alarm indicator (30 of Figure 1) is triggered per block 114 and a preprogrammed telephone number is dialed and indicator 32 is lit (block 116).

After the alarm condition is manually checked and the system is reset, the output of block 120 will be a "yes" and the system will be reset to normal (block 112). If a valid alarm condition is indicated and confirmed, civil authorities will have time (usually several days) to notify the populace, evacuate the area, or take any other needed precautions, depending on the size of the impending quake as indicated by the size of the standard deviation.

Programs

The attached computer programs will perform the calculations and operations above described. These programs are written in the BASIC programming language. Program "RECVOLT.AL" runs continuously and writes the information to disc every 24 hours. Program "GRASTAT.*" is manually run; it reads data from the disc and plots it on the screen or printer, as desired.

While the above description contains many specifications, these should not be construed as limitations on the scope of the invention, but merely as an exemplification of one preferred embodiment thereof. Many other variations are possible. For example, the programming language can be changed, or the calculations and operations can be performed with hard-wired conventional circuitry in lieu of a programmed computer. More than two corroboration receivers can be used, and these can be placed at various locations. In lieu of testing the antenna's output reception of the area's AM stations, a special, dedicated transmitter with a special, dedicated frequency and a specially-tuned matching receiver can be used to avoid dependence on stations which are not under the control of the earthquake prediction system and its personnel. The transmitter and the receiver should be spaced apart geographically, preferably by at least several km, so that the ground plane conduction phenemonon can operate. Also the transmitted signal can be a specially-coded or modulated signal, or it can be an auxiliary signal of a regular transmitter, e.g., a SSB or SCA signal, together with a matching receiver. In lieu of a test for an excess SD, the apparatus can be arranged to test for a predetermined drop in the value of the antenna output from its immediately previous value or its average value over a predetermined period, such as an hour or day, or for a drop having greater than a predetermined slope. Accordingly the full scope of the invention should be determined by the appended claims and their legal equivalents, and not by the examples given.

Claims -- [Not included here]

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rexresearch.com

Joe TATE

Ambient Power Module

Joe Tate's Ambient Power Module (APM) converts radio frequencies to usable electrical power (albeit only milliwatts) sufficient to operate clocks, smoke alarms, Ni-Cd battery chargers, &c. It also can provide early seismic warning since earthquake preparation generates radio frequencies. It also acts as a proximity detector for ships & structures.

The Amazing Ambient Power Module
Radio Waves Singal Earthquakes
Radio Earth: The Radio-Seismic Connection
US Patent # 4,628,299: Seismic Warning System Using RF Energy Monitor

The Amazing Ambient Power Module

Parts List for the APM-2

Four 1N34 germanium diodes (Radio shack #276-1123) ~ Figure 1, X1, X2, X3, & X4
Two 0.2 mfd 50 V ceramic capacitors ~ Figure 1, C1 & C2
Two 100 mfd 50V electrolytic capacitors (Radio Shack #272-1016) ~ Figure 1, C3 & C4
Copper wire for antenna & ground connections

Introduction

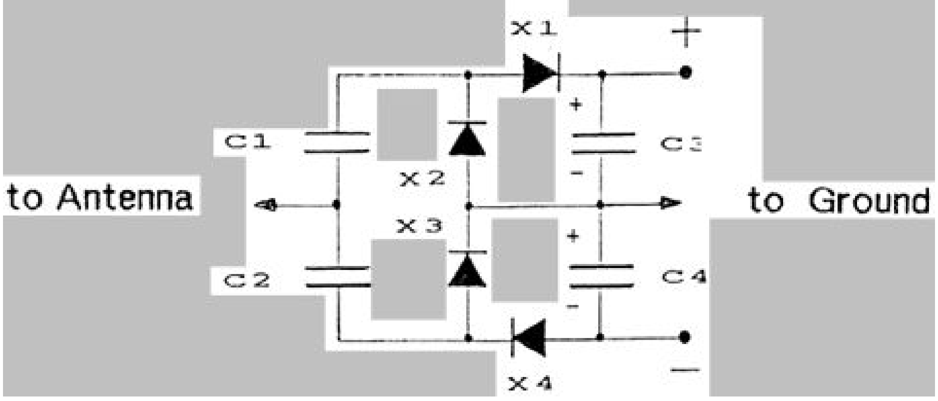
The Ambient Power Module (APM) is a simple electronic circuit which, when connected to antenna and earth ground, will deliver low voltage up to several milliwatts. The amount of voltage and power will be determined by local radio noise levels and antenna dimensions

Generally a long wire antenna about 100' long and elevated in a horizontal position about 30' above ground works best. A longer antenna may be required in some locations. Any type copper wire, insulated or not, may be used for the antenna. More details about the antenna and ground will be discussed further on.

The actual circuit consists of two oppositely polarized voltage doublers (Figure 1). The DC output of each doubler is connected in series with the other to maximize voltage without using transformers. Single voltage doublers were often found in older TV sets for converting 120 VAC to 240 VDC. In the TV circuit the operating frequency is 60 Hz.

FIG. 1

APM-2 SCHEMATIC DIAGRAM



The APM operates at radio frequencies, receiving most of its power from below 1 MHz. The basic circuit may be combined with a variety of voltage regulation schemes, some of which are shown in Figure 2. Using the APM-2 to charge small NiCad batteries provides effective voltage regulation as well as convenient electrical storage. This is accomplished by connecting the APM-2 as shown in Figure 2B.

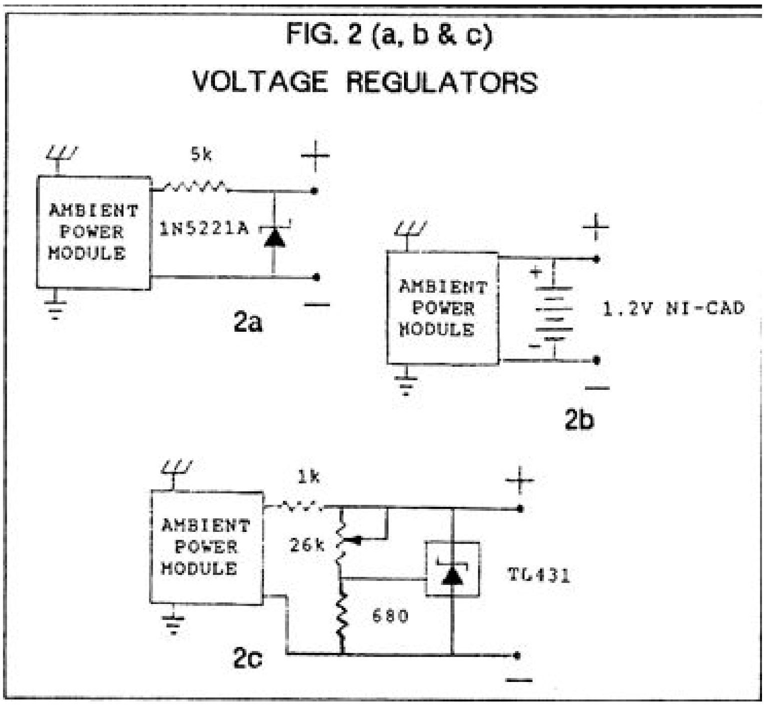


FIG. 2 (a, b & c)
VOLTAGE REGULATORS

Charging lead acid batteries is not practical because their internal leakage is too high for the APM to keep up with. Similarly, this system will not provide enough power for incandescent lights except in areas of very high radio noise.

It can be used to power small electronic devices with CMOS circuitry, like clocks and calculators. Smoke alarms and low voltage LEDs also can be powered by the APM.

Figure 3 is a characteristic APM power curve measured using various loads from 0-19 kOhm. This unit was operating from a 100' horizontal wire about 25' high in Sausalito CA. As can be seen from the plot, power drops rapidly as the load resistance decrease from 2 kOhm. This means that low voltage, high impedance devices, like digital clocks, calculators and smoke alarms are the most likely applications for this power source. Some applications are shown in Figures 4 through 7.

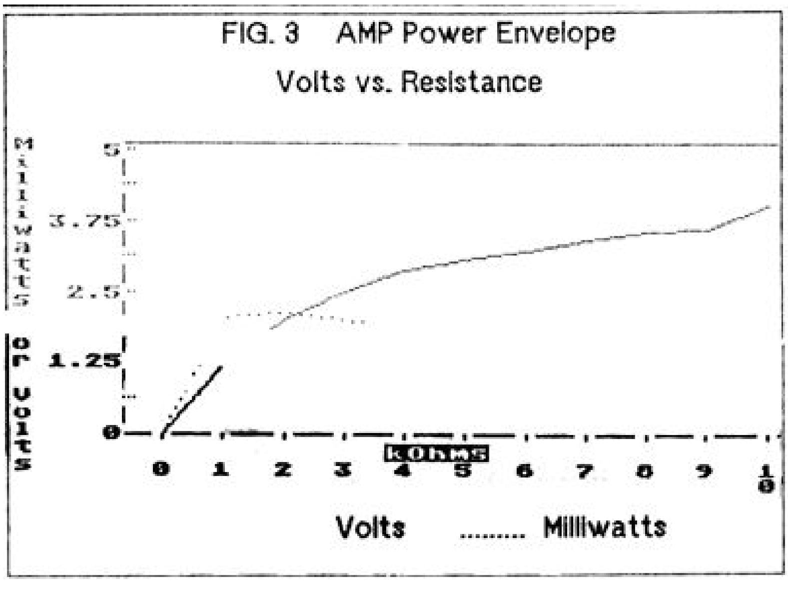


FIG. 3 AMP Power Envelope
Volts vs. Resistance

Figure 4 ~ A digital clock is shown powered by the APM-2. The 1.5 volt clock draws 28 microamps. Its position on the power envelope curve would be off the scale to the right and almost on the bottom line, dissipating only 42 microwatts.

FIG. 4 Clock powered by APM

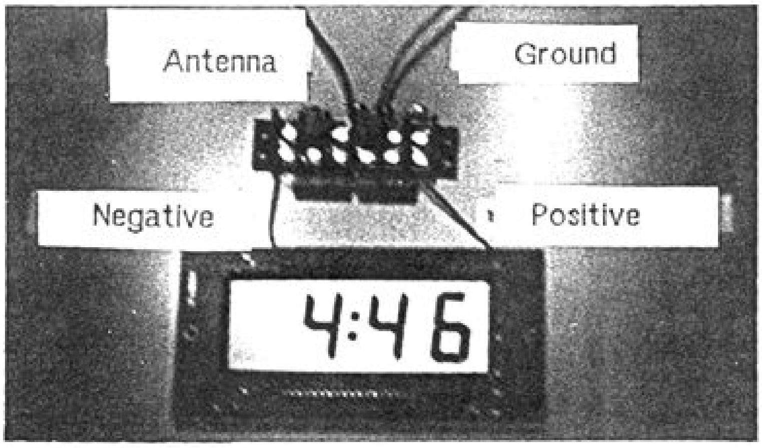


FIG. 5 APM charging a battery

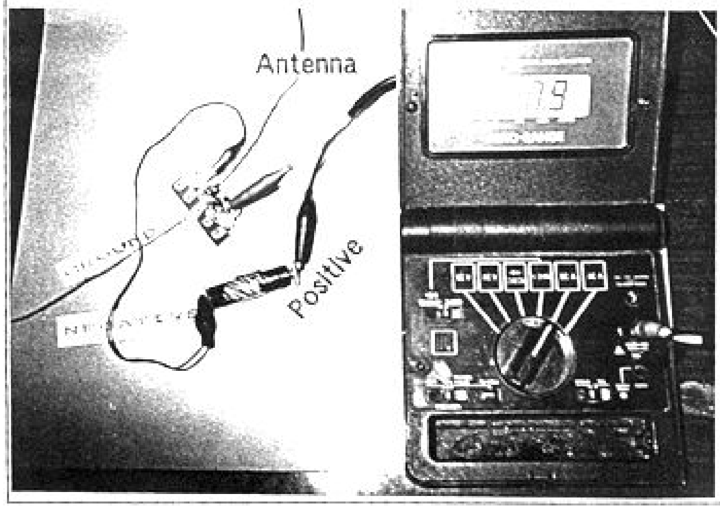


Figure 6 shows a clock which has the APM-2 built into it so it is only necessary to connect the antenna and ground wires directly to the clock. The antenna for this clock, which is a low frequency marine type, is shown in Figure 7.These antenna are expensive, not generally available, and usually don't work any better than the long wire mentioned above. But it may be necessary to use them in urban areas where space is limited and radio noise is high.

FIG. 6

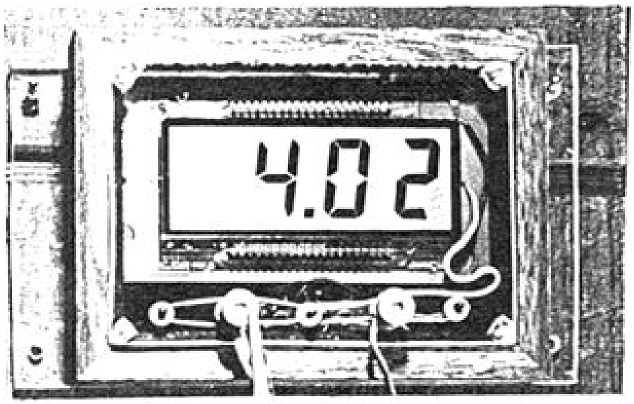
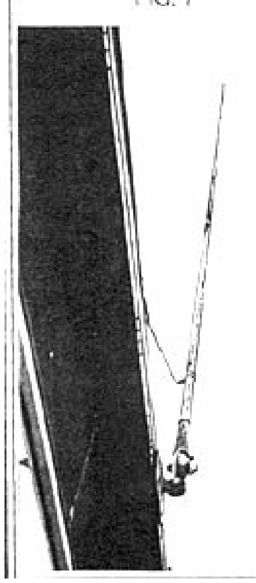


FIG. 7

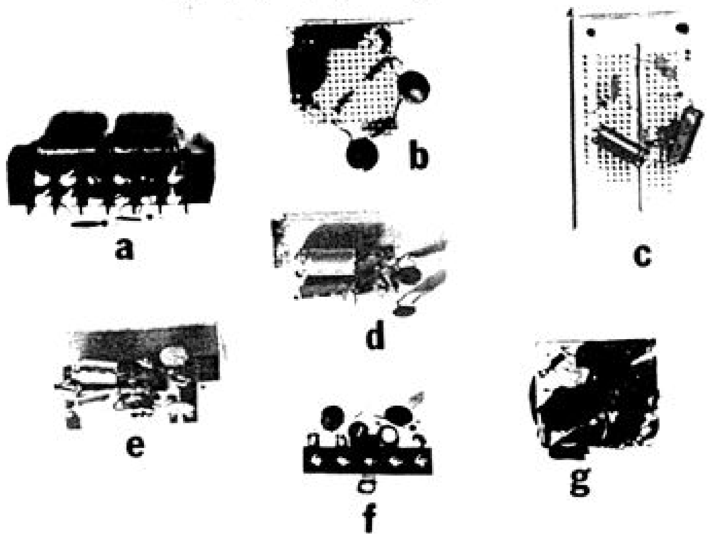


Building the Module

The builder has a choice of wiring techniques which may be used to construct the module. It may be hand wired onto a terminal strip, laid out on a bread board, experiment board, or printed circuit. Figure 8 shows some of the different ways of constructing the APM-2.

Figure 8A is constructed on a screw strip terminal; Figure 8B is constructed on a perforated breadboard; Figure 8C is built on a standard experiment board; Figures 8D, 8E, and 8F are all printed circuits; Figure 8F is made up on a solder strip terminal.

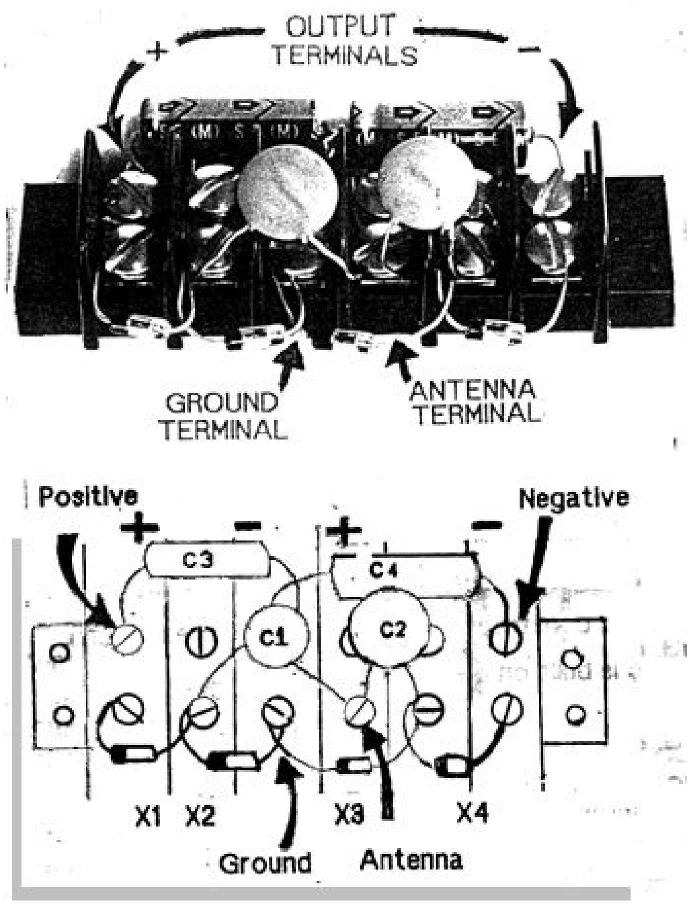
FIG. 8 a, b, c, d, e, f & g



If you wish to make only one or two units, hand wiring will be most practical, either on a terminal strip or breadboard. Assembly on the terminal strip (Figure 8A) can be done easily and without soldering. It is important to get the polarity correct on the electrolytic capacitor. The arrow printed on the side of the capacitor points to negative.

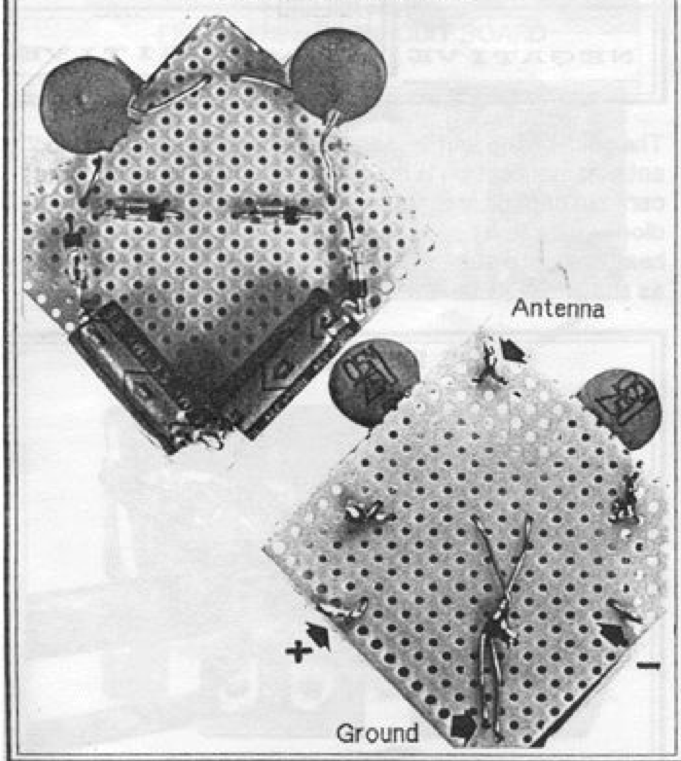
Figure 9 is a closer view of the terminal strip with an illustration of the components and how they are connected.

FIG. 9 TERMINAL STRIP



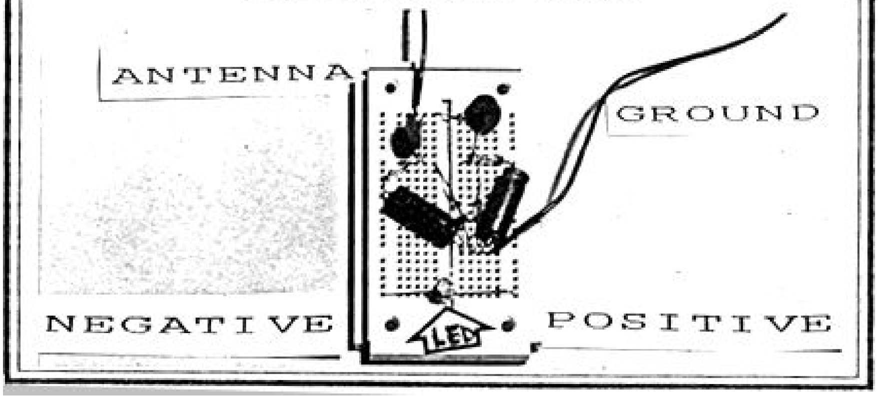
The breadboard unit is shown in Figure 10 with all components on one side and all connections on the other. All you need is a 2" x 2" piece of perforated breadboard (Radio Shack #276-1395) and the components on the parts list. Push component wires through the holes and twist them together on the other side. Just follow the pattern in the photo, making sure to observe the correct polarity on the electrolytic capacitors and the diodes. The ceramic capacitors may be inserted in either direction.

FIG. 10 BREADBOARD



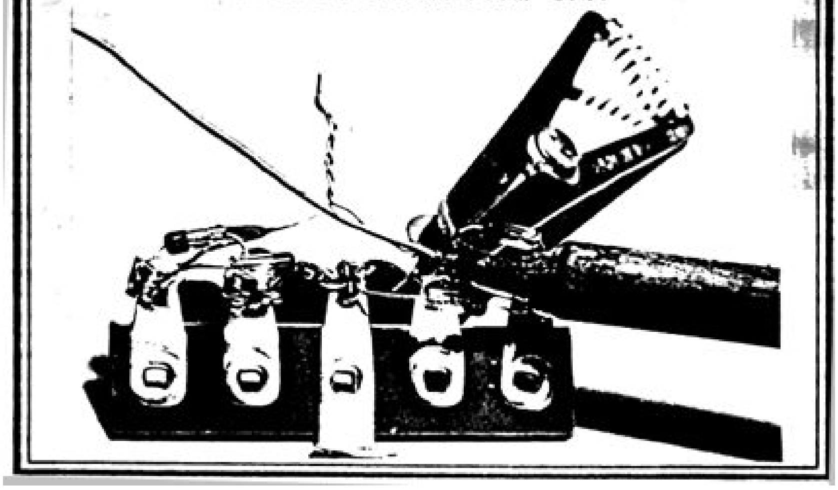
The experiment board unit is assembled by simply pushing the component leads into the board as shown in Figure 11. This unit is powering a small red LED indicated by the arrow.

FIG. 11 EXPERIMENT BOARD



The solder strip unit is made up on a five terminal strip. The antenna connection is made to the twisted ends of the ceramic capacitors. When soldering the leads of the 1N34 diodes, care must be taken to avoid overheating. Clip a heat sink onto the lead between the diode and the terminal as shown in Figure 12.

FIG. 12 SOLDER STRIP UNIT



It is beyond the scope of this pamphlet to show how to make printed circuits, but the layout of the board is provided in Figure 13.

FIG. 13

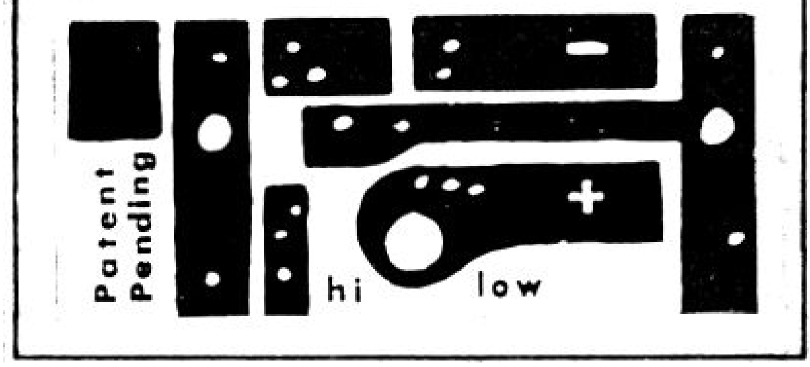
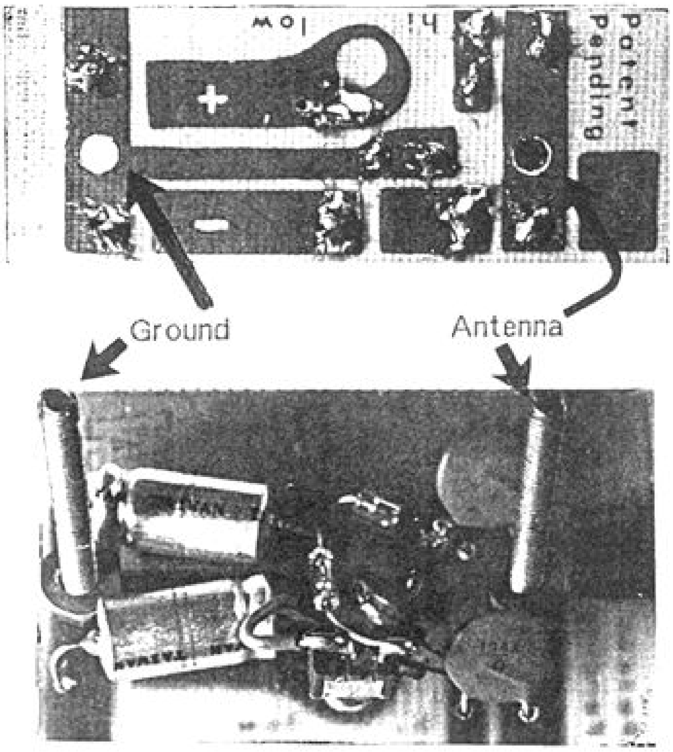


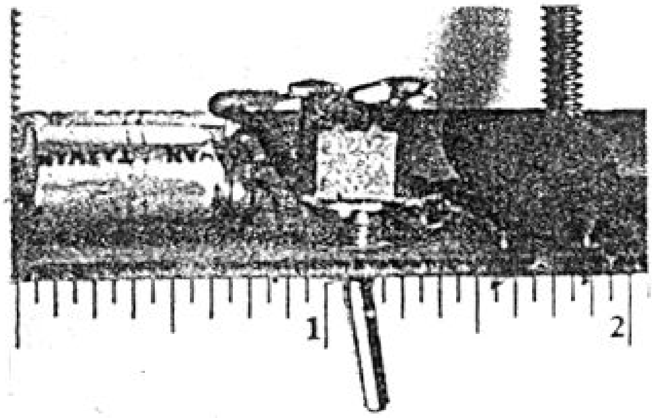
Figure 14 shows the front and back view of the completed printed circuit.

FIG. 14 PRINTED CIRCUIT BOARD



A small switch may be installed on the board to activate the zener regulator (Figure 15). This board was designed for use in clocks.

FIG. 15



Antenna Requirements

The antenna needs to be of sufficient size to supply the APM with enough RF current to cause conduction in the germanium diodes and charge the ground coupling capacitors. It has been found that a long horizontal wire works best. It will work better when raised higher. Usually 20-30 feet is required. Lower elevations will work, but a longer wire may be necessary.

In most location, possible supporting structures already exist. The wire may be stretched between the top of a building and some nearby tree or telephone pole. If live wires are present on the building or pole, care should be taken to keep your antenna and body well clear of these hazards.

To mount the wire, standard commercial insulators may be sued as well as homemade devices. Plastic pipe makes an excellent antenna insulator. Synthetic rope also works very well, and has the advantage of being secured simply by tying a knot. It is convenient to mount a pulley at some elevated point so the antenna wire may be pulled up to it using the rope which doubles as an insulator (Figure 16).

FIG. 16

Pulley & Wire

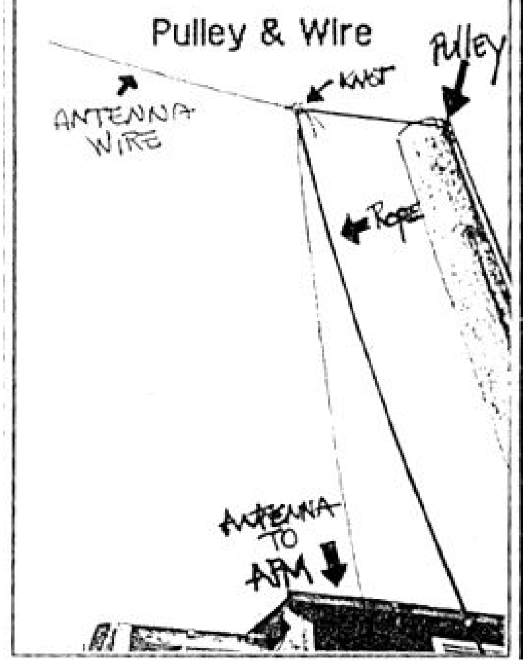
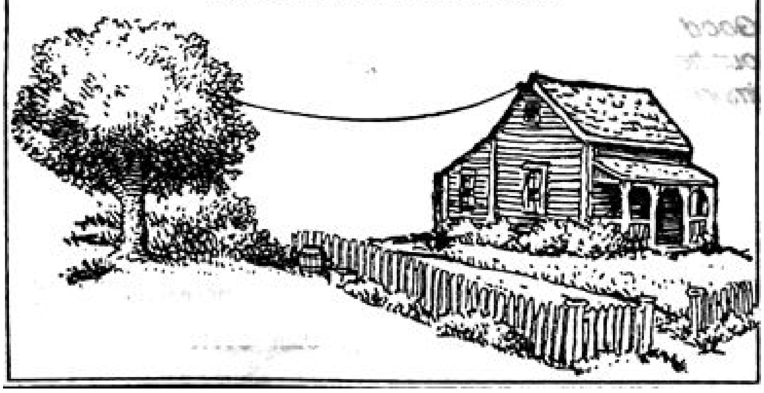


Figure 17 is an illustration of a horizontal wire antenna using a building and tree for supports.

FIG. 17

Horizontal Wire Installation



Grounding

Usually a good ground can be established by connecting a wire to the water or gas pipes of a building. Solder or screw the wire to the APM-2 ground terminal. In buildings with plastic pipes or joints, some other hookup must be used. A metal rod or pipe may be driven into the ground in a shady location where the earth usually is damper. Special copper coated steel rods are made for grounds which have the advantage of good bonding to copper wire. A ground of this type usually is found within the electrical system of most buildings.

Conduit is a convenient ground provided that the conduit is properly grounded. This may be checked with an ohmmeter by testing continuity between the conduit and system ground (ground rod). Just as with the antenna, keep the ground wire away form the hot wires. The APM's ground wire may pass through conduit with other wires but should only be installed by qualified personnel.

Grounding in extremely dry ground can be enhanced by burying some salts around the rod. The slats will increase the conductivity of the ground and also help retain water. More information on this subject may be found in an antenna handbook.

Good luck getting your Ambient Power Module working. It is our hope that experimenters will find new applications and improve the power capabilities of the APM.

***Science News* [date unknown]**

Radio Waves Signal Earthquakes

From the bright flashes reported to appear in the sky during strong earthquakes to computer breakdowns during severe tremors, scientists have long suspected that seismic activity is associated with a variety of electrical effects. Recently researchers have been taking a careful look at this link, with an eye toward using it to predict earthquakes.

One such study is being conducted by Joseph Tate of Ambient Research in Sausalito, CA, and William Daily at Lawrence Livermore National Laboratory in Livermore, CA. With a system of radio wave monitors distributed along California's San Andreas fault, the researchers have recorded two kinds of changes in atmospheric radio waves prior to earthquakes that occurred between 1983 and 1986.

The most common change is a drop in the radio signals that normally pervade the air as a result of lightning and human sources such as car ignition systems and electric power grids. This reduction typically occurs one to six days before an earthquake and can last for many hours. For example, a magnitude 6.2 earthquake that shook Hollister CA in April 1984 was preceded six days earlier by a 24-hour drop in radio signals being monitored 30 miles from the quake's epicenter. Tate and Daily have found that the larger the earthquake, the longer the time between the radio wave depression and the quake.

Laboratory studies have shown that the electrical conductivity of rocks increases as they are stressed. Based on this and their electrical modeling of the ground, Tate and Daily think the increased conductivity of stressed rocks near the fault causes more radio waves to be absorbed by the ground rather than their traveling through the air. They also plan to test a possible link between radio wave drops and the emission of radon gas, which itself is thought to be a quake precursor. The radon may ionize the air, making it temporarily more absorptive than the detector antenna.

The researchers have also found, in addition to these drops, another prequake phenomenon in which short pulses of increased radio wave activity are emitted. For example, five days before the magnitude 6.5 earthquake hit palm Springs CA in July 1986, a station 15 miles from the epicenter detected a rise in radio signals. This sort of emission is consistent with laboratory work showing that cracking rocks release electromagnetic signals.

Tate says that in their first attempts at predicting earthquakes in 1984 and 1985, they did not miss a single event, so he his optimistic about using this technique for short-term forecasting of San Andreas quakes. "In three to five years", he says, "we should be able to issue [earthquake] warnings."

Whole Earth Review **(Fall 1990, pp. 101-104)**

Radio Earth: The Radio-Seismic Connection

by

Joe Tate

Since the earliest days of radio research, many people have thought of these invisible waves as artificial, an effect created solely by wizards in a laboratory. Later, in the 1930s, Karl Jansky discovered radio emissions coming from the Milky Way. Stars are now known to be giant transmitters, broadcasting a spectrum of electromagnetism from low-frequency noise to gamma rays. So much for the artificiality of radio.

Even in the 19th century, in the days of Tesla and Edison, radio noise caused by lightning was known to have recognizable propagation patterns. It was these patterns that Jansky was measuring when he discovered cosmic radio.

Tesla actually calculated the resonant frequency of the Earth, and proposed that electromagnetic waves of this frequency (6-8 Hz) should be generated by the planet from the action of lightning. These "Schumann resonances", as they came to be known, were finally detected in the 1960s.

Other strange radio emissions were noticed at about the same time, a time when many new radio observatories were starting operation at various places around the world. The observatories could each detect and record a wide range and volume of electromagnetic radiation (EMR). Before and during the great Chilean earthquake of 1960, unusual strong signals were received at six widely scattered radiotelescopes. The connection between these radio signals and the earthquake was eventually shown by James Warwick of the University of Colorado, who analyzed the observatories' separately recorded data (Figure 1) [Not shown]. Earthquakes generate radio waves! But how?

Twenty-two years later, after performing a series of laboratory experiments in which rocks were crushed in powerful presses and the resulting electromagnetic emissions were measured, Warwick's paper describing the phenomenon appeared in the April 1982 issue of the *Journal of Geophysical Research*.

In the meantime, other experimenters had recorded similar effects in Japan, France, the United States and the Soviet Union. Several studies of satellite data revealed marked increases in very-low-frequency (VLF) emissions from epicenter regions before and during major earthquakes. In Greece, researchers found that telluric currents (natural currents of electricity flowing in the Earth) fluctuated prior to earthquakes.

Ambient Power

In 1979, I was experimenting with methods of turning radio energy in the air into usable electric power. I developed a clock which drew its power from an antenna that was just a long piece of wire stretched out horizontally about 20 feet above the ground.

The power supply for the clock worked something like an old-style crystal radio, except that it did not have a tuning circuit. Because of this, the Crystal Clock (as I called it) was able to absorb a wide spectrum of radio noise from the antenna and yield electric power. The power supply was able to deliver much more current than was developed in a crystal radio, although its output was still just a few millivolts.

In the early 80s I demonstrated the clock to the late Frank Oppenheimer, then director of San Francisco's Exploratorium, where I worked in the exhibit repair shop. Oppenheimer suggested

recording the power supply's output over a long period of time to determine its dependability. After all, the device relied completely on whatever stray signals happened to be in the air.

Using an Atari computer which had been donated to themuseum, the oputput of the clock's power supply was measured continuously and recorded on floppy disk. This was done by feeding the unregulated voltage output direcly into the coputer's joystick port.

I began calling this power supply the "Ambient Power Module" (APM) because it extracted power from ambient background radio noise. This small circuit, when connected to antenna and ground, used the potential difference between air and ground to generate a small direct current continuously.

As we studied the recorded data, mild fluctuations were noted in a daily cycle. The patterns were consistent over long periods of time, though they differed in different locations. Aside form that, the APM looked like a very dependable source of power. Until the spring of 1984.

On April 24, 1984, a 6.0 magnitude earthquake struck about 90 miles from the APM recording station in Sausalito. Days later, while looking through the data, I noticed that the APM output dropped to less than half its normal value for several hours during the afternoon 6 days before the earthquake (Figure 2) [Not shown] this was very peculiar, because most of the APM's power came from broadcast signals, and broadcasting stations hadn't done anything different that afternoon. Apparently something had temporarily depressed the propagation of radio waves. At high frequencies, such effects can be caused by atmospheric conditions. But the lower frequencies involved here are hardly affected, particularly not the signals from the nearest stations, which account for most of the power received. It was tempting to think this strange radio depression might somehow have been a precursor to the earthquake.

Several smaller quakes had occurred in the area during the year before. Perhaps these also were preceded by similar radio anomalies. Looking back through the accumulated data on the APM's power output, indeed, smaller, less obvious radio depressions were found to occur prior to the lesser earthquakes.

I called the US Geologic Survey (USGS) office and told them about these radio events. I learned from them that ham operators in the area had also reported radio noises accompanying earthquakes, but no one had recorded them. Jack Everenden, with whom I was speaking, asked for copies of my data, which I sent.

Two weeks later, William Daily of Lawrence Livermore Labs called, asking if I would like to work with him gathering earthquake radio noise data under a grant from the USGS.

Radio Earth

For the next three years we deployed monitoring/recording devices along the San Andreas fault, from San Francisco to San Diego. The units were battery-powered paper-chart recorders which could hold one month's worth of data. They recorded radio noise levels in three adjacent bands: 0.2-1, 1-10 and 10-100 kHz. In addition we continued using the APM recorders in two locations, Sausalito and San Mateo.

During this period, some 46 earthquakes 4.0 and above occurred within 120 miles of our stations. Of these, 32 quakes were preceded by a radio anomaly. Only five quakes were not preceded by radio precursors. These were also ten false positives (radio events with no quakes following). These may have been caused by earthquake prepartion forces which failed to mature. Either way, our score was about 70%.

The results of our study were published in October 1989, just as the Loma Prieta Earthquake struck northern California.

By this time we had dismantled our network of recording stations. However, one of the original APM recorders was still running at my lab in Sausalito. This instrument recorded the largest radio depression I have ever seen, about 60 days prior to the October 17 shocks (Figure 3) [Not shown]. I had reported that event to Galilee Harbor's board of directors, but no action was taken.

In studying several smaller earthquakes from 1985-1987, it appeared that the larger the earthquake, the larger and sooner the precursors appeared. The 6.0 earthquake of April 24, 1984 was preceded by a radio depression 6 days before the shock. The Loma Prieta Earthquake of about 7.0 magnitude was preceded by a much greater radio depression 60 days before. A 7.0 magnitude quake is 10 times greater than a 6.0. The 60-day precursor time for the 7.0 earthquake was 10 times the precursor time for the 6.0 earthquake. More data is needed to clarify this relationship.

Warrick's lab showed that fracturing rocks generate radio waves: when Westerly granite was crushed in a shielded space, a receiving antenna detected broadband signals ranging from 500 kHz to 30 MHz. Most of the energy was concentrated at the lower frequencies.

Other experimenters measured changes in the electrical resistance of rocks under pressure. During the late 1970s, William Brace of MIT compressed various rocks in a powerful press while recording their resistance. He found that as rocks approach fracture pressure, they become much more electrically conductive. A related experiment by William Daily at Lawrence Livermore Lab subjected rocks to evenly distributed pressure while their electrical resistance was measured. Under uniform pressure, the rocks did not show the changes in resistance produced in Brace's press. That suggested it was stress caused by force being applied unevenly which caused the observed changes in resistivity.

Although Warwick's experiment proved rocks can emit radio waves during crushing, calculations showed that any such waves generated far underground would be absorbed by the earth, never reaching the surface with enough energy to be detected in the atmosphere. In addition, this effect could not explain the decrease of ambient radio energy observed by us and others.

Takeo Yoshino, of the University of Electro-Communications in Tokyo, has proposed that "resistance slots" form along a fault line due to effects similar to those demonstrated by Brace. Yoshino argues that if ground resistance becomes high enough in these slots, then radio waves coming from below will pass through them, rather than being absorbed, and enter the atmosphere. It would also mean atmospheric radio energy could pass into the earth through these slots. This could create interesting resonant effects.

Does ground resistance actually reach the levels needed to sustain such an effect? It is known that ground water enhances ground conductivity. However, C.B. Raleigh of the USGS has calculated that enough heat can be produced by friction during the earthquake preparation process to boil the ground water out of a rupture zone. Perhaps dehydration could combine with stress-induced fluctuations in rock resistance to produce slots of heightened electrical resistance in the earth's crust.

Based on this idea, it is my belief that the radio depressions and emissions recorded by us and others are the result of fluctuations in ground radio absorption.

Radio waves moving through the atmosphere are always being partly absorbed into the ground. The absorption rate varies from place to place, based on the ground's conductance and the distribution of rocks and sediments. If anything alters this equilibrium, the radio fields in the atmosphere should also be affected. For instance, more ground absorption should result in a lower intensity in the atmosphere. A loss of absorption would produce increased intensity in the atmosphere. Seismic radio events may be due to this effect.

As a model for explaining the observed radio anomalies, this has appeal, since it can account for both radio emissions and depressions. It could also explain the changes in telluric currents recorded

in Greece prior to earthquakes. As ground conductance changes, currents flowing through the Earth may be diverted to channels and zones of greater conductance.

As more data is gathered, we'll understand more about these phenomena. In the meantime, though, we're on a slow learning curve, limited by the frequency of large earthquakes. There is really no way to speed up this process, and perhaps we don't actually want to.

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US Patent # 4,628,299

Seismic Warning System Using RF Energy Monitor

Joe Tate, et al.

Abstract -- The ambient broadband radio frequency field strength from broadcast stations is monitored (Figure 4) by periodic sampling (50, 52). A warning indication is provided if the field strength drops significantly. Drops in such field strength have been correlated empirically with the occurrence of seismic activity, usually several days later. Thus the indication serves as an early warning of an impending earthquake. In one preferred embodiment, a broadband, horizontal, very long monopole antenna (40) was connected to a rectifying and smoothing circuit (Figure 3) to provide a dc output proportional to the ambient rf field. This voltage is digitized (50), and using a suitably programmed computer (52), the digital version of the field strength signal is sampled once per minute (78). A cumulative or running average of the minute samples is calculated (80) and held. Once per hour the latest running average is stored (84) and a standard deviation (SD) of the last 24 hourly stored running averages is calculated (88). If the SD exceeds a predetermined value, 0.3 in one embodiment, an alarm is triggered (92). The use of the SD eliminates the effect of day-to-day changes in the amounts of the variations of the ambient field strength, due to changes in tides and other factors. Once per day the samples are written (96) to a permanent storage file and a continuous plot of the field strength is also made (14). Preferably the alarm is triggered only if another detector also provides an indication (FIG. 6), thereby to eliminate the effect of machine error.

Inventors: Tate; Joseph B. (Sausalito, CA); Brown; David E. (Mill Valley, CA)
Assignee: Pressman; David (San Francisco, CA)
Appl. No.: 695632; Filed: January 28, 1985
Current U.S. Class: 340/540; 324/323; 324/344; 340/600; 340/690; Intern'l Class: G08B 021/00
Field of Search: 340/540,600,690

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U.S. Patent Documents

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4,364,033, Dec., 1982, Tsay 340/540.

Description

Background: Field of Invention

This invention relates to the prediction of the fugure occurrence of seismic activity, particularly to the advance notification of earthquakes through the monitoring of ambient radio frequency (rf) energy.

Background: Description of Prior Art

Heretofore, insofar as we are aware, seismology, the science of earthquakes, has not been able to make any near-term predictions of earthquakes.

While scientists have known that certain animals may have had some sort of advance knowledge of quakes, due to the fact that they exhibited peculiar behavior before quakes, and not at other times, this behavior has not been consistent and reliable enough to be of practical use.

Also, while scientists have also been able to predict thunderstorms in advance by monitoring the ambient electrostatic field (see, e.g., US Pat. No. 3,611,365 to Husbyorg and Scuka, 1968; 3,790,884 to Kohl, 1974; and 4,095,221 to Slocum, 1978), they have not been aware of any corresponding system for earthquake prediction.

Scientists have been able actually to detect earthquakes during their occurrence by monitoring air pressure variations (e.g., as described in US. Pat. No. 4,126,203 to Miller, 1978) and by monitoring the earth's physical movement by seismographs but, again, science has not been aware of any system for short-term advance detection or prediction of quakes.

Due to the devastating effects of quakes to property, life, and limb, public and governmental authorities would derive great benefit from any system which could provide short-time advance notification of great earthquakes. As it is now, except for aftershocks, which seismologists know will occur after any large quake, all great and small quakes occur without warning. Because people in the vicinity of such quakes are unprepared, they often are in places of great vulnerability, such as beside or inside collapsible buildings, so that severe and human injury usually occurs during a quake. Also, property itself is left vulnerable, e.g., by leaving automobiles in or near collapsible buildings, leaving gas and electricity connected such that disruption of these facilities causes fires, and leaving other valuable property in vulnerable areas. If advance notification of a large quake could be provided to the public and civil authorities, people and valuable property could be evacuated and protected, thereby preventing deaths, injuries, and greatly reducing property damage. Further, advance notification of quakes would eliminate the severe psychological trauma which often affects large segments of the populace due to the surprise occurrence of quakes.

Objects & Advantages

Accordingly several objects and advantages of the invention are to provide a reliable and effective method of earthquake prediction, to provide a method of preventing death, injuries, and reducing property damage in earthquakes, and to provide a method of reducing the psychological trauma which often accompanies quakes due to their surprise occurrence. Additional objects are to provide such a system which is easy to use, economical, reliable, and portable. Further objects will become apparent from a consideration of the ensuing description, taken in conjunction with the accompanying drawings.

Background: Theory of Invention

The following is a discussion of the background theory of the invention. While we believe it to be technically accurate, we do not wish to be limited by this theory since the operability of the invention has been empirically verified, as will be apparent from the later discussion.

We have recently worked work with the reception and utilization of broadband radio-frequency reception, e.g., for low-power utilization applications, as discussed in the copending application Ser. No. 06/539,223 of Joseph B. Tate, filed Oct. 6, 1983. While doing this work, we have noted that the antenna's output voltage fluctuated with time due to certain, known causes.

First, we noted that the higher we placed an antenna above the ground, the the greater the output signal it provided. We have observed this by raising the physical height of an antenna and observing an increase in power output, and also by observing variations in the output of a fixed antenna near a body of ocean water as a function of the tides: the antenna's output was greatest at low tide and lowest at high tide. We believe that the change in water level, which serves as a ground plane, effectively lowers or raises the height of the antenna above the ground.

We also noted that the antenna's output was affected by solar flares to a limited extent; these caused the antenna to produce a higher output voltage during their occurrence. We believe this phenomena is caused by an increase in the level of ambient ionization due to the flares.

Further, we noted that the antenna's output dropped at certain irregular times; at first we would not attribute any cause to these drops. However investigation enabled us to correlate these drops with the subsequent occurrence of seismic activity. We found that the magnitude of the drop was proportional to the size of the subsequent earthquake.

Certain phenomena have been discovered to precede earthquakes. These include an anomalous uplift of the ground, changes in the electrical conductivity of rock, changes in the isotopic composition of deep well water, changes in the nature of small earthquake activity (e.g., bunching of small foreshocks), anomalous ground tilt or strain changes, changes in physical properties, such as porosity, electrical conductivity, and elastic velocity in the hypocentral region. *Earthquake, McGraw-Hill Encyclopedia of Science And Technology*, 1960; *Earth* by F. Press, W. H. Freeman & Co., 1974.

Phenomena associated with rocks have attracted much recent attention. Wm. Brace of the Mass. Inst. of Technology has found that when rocks were squeezed or compressed, just before they fractured, they tended to develop hairline cracks, swell or dilate (dilatancy), become more porous and electrically conductive, and transmitted high frequency seismic-like waves more slowly. Two of Brace's former students, Amos Nur of Stanford University and Christopher Scholz of Lamont-Doherty furthered Brace's work, connecting the dilatancy theory with seismic P-wave velocity shifts and rock resistivity changes as a precursor for earthquakes. See. e.g., Brace, Orange, and Madden, *J. Geophys. Res.*, 70(22), 5669, 1965; A. Nur, *Bull. Seis. Soc. of Amer.*, V 62, Nr. 5, pp. 1217-1222, 1972 Oct.; *Earthquake* by B. Walker, Time-Life Books, 1982.

Based upon the above background, we have developed a theory as to the cause of this drop in antenna output as a precursor or predictor of earthquakes. We believe that before a quake occurs, the pressure within underground rock bodies temporarily increases greatly, causing the rocks to dilate and become conductive, in accordance with the works of Brace, Nur, and Scholz. This increase in conductivity effectively raises the ground plane, thereby causing the antenna's output to decrease temporarily.

Thus before the occurrence of a quake, the underground pressure increases greatly temporarily, causing underground rock bodies to swell and become more conductive, thereby raising the ground plane, which in turn causes the voltaic output of nearby antennas to drop.

We accordingly constructed an apparatus to automatically monitor antenna output and provide a suitable indication if the output level dropped significantly. The indication was calibrated empirically after much experimentation so as to filter out the effects of solar- and tide-caused variations. We did this by arranging the apparatus so that an output indication was provided only if the antenna output dropped a predetermined degree beyond its average level; we utilized statistical filtering techniques to accomplish this.

Drawings

Figure 1 shows the front panel of a Seismic Early Warning (SEW) apparatus according to the invention.

Figure 2 is a plot of voltage (representing ambient rf level) v. time as measured by the apparatus of Figure 1.

Figure 3 is a schematic diagram of an ambient power module circuit (used in the SEW apparatus) for producing a DC output voltage proportional to the ambient rf energy

Figure 4 is a block diagram of a computer in the apparatus of Figure 1.

Figure 5 is a flowchart which depicts the operation of the SEW system.

Figure 6 is a flowchart which depicts the operation of an optional alarm trigger system useable with the SEW apparatus.

Figure 1: Seismic Early Warning Apparatus

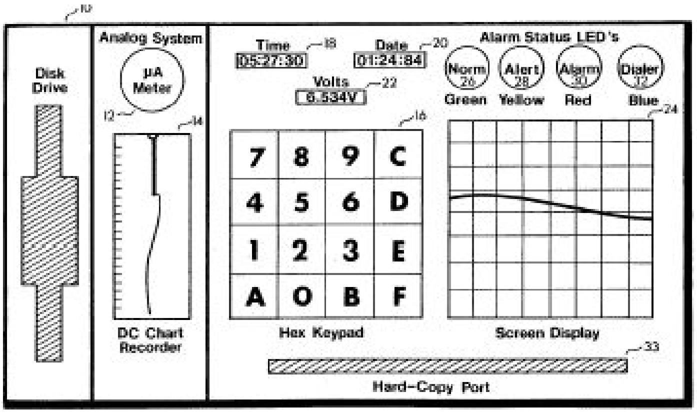


FIG 1

In accordance with the invention, a seismic early warning apparatus is provided as shown in FIG. 1. The apparatus consists of a housing containing a general purpose computer (not shown), a disc drive 10, an analog system comprising a microampere meter 12 arranged to monitor direct current (which is proportional to the ambient rf energy), and a direct current strip chart recorder 14 arranged to provide a continuous indication of the current antenna output, which will be called the ambient power level. A hexidecimal keypad 16 is provided to enter data, such as time, for entering programs and changes and for operating the system according to preset codes. The time, date, and voltaic level of the antenna's output are continuously indicated by digital readouts 18, 20, and 22, respectively. A screen display 24 is provided to display graphic and alphanumeric information of the current status of the apparatus and previous data records.

Lastly the apparatus includes four status-indicating lamps, which preferably are LEDs (light-emitting diodes) as follows: A green LED 26 indicates that the system is on and functioning normally. A yellow LED 28 indicates that the system has detected an event, namely the occurrence of a drop in ambient power below the preset level, which would be the prediction of an impending earthquake. A red LED 30 is provided as backup confirmation of the occurrence of the event; LED 30 is illuminated when a duplicate receiving system also detects an event. A blue LED 32 indicates initiation of operation of an automatic telephone dialer within the system, which has been preprogrammed to dial a predetermined number and provide a warning in the event of an occurrence of an alarm condition. Lastly the apparatus includes a hard copy output port 33 for providing printed graphic and numeric outputs of all system data.

Figure 2: Ambient RF Level vs Time Before Quake

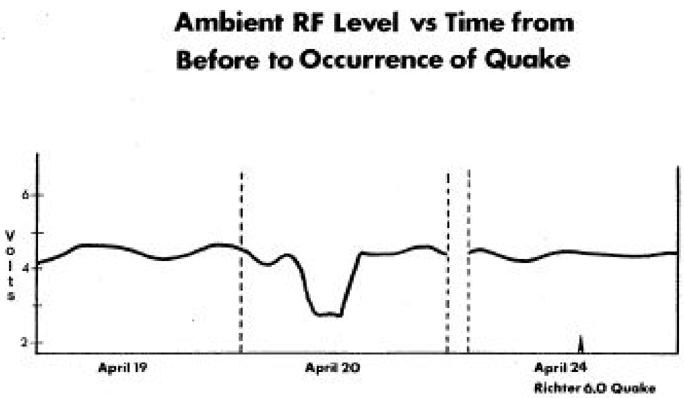


FIG 2

Figure 2 illustrates a reproduction of an actual plot of a voltage as a function of time, which voltage was proportional to the ambient RF (radio frequency) level, from the period from before to after a

relatively large earthquake. This plot, which is typical of many we have observed before a quake, was made by deriving the voltage with a 30-meter, long-wire monopole antenna (not shown) which was mounted horizontally and which extended over San Francisco (Richardson) Bay easterly from Sausalito, California, 9 meters above sea level. The antenna thus intercepted and converted to an RF voltage the ambient RF energy, mainly from local (San Francisco area) AM radio stations. We rectified and filtered the output of the antenna using one-half of the circuit of FIG. 3 (described below) to provide a DC voltage which was plotted on a conventional ink-on-paper plotter. Note that on the section of the chart for Apr. 19 (1984), which begins at time 0:00 (midnight) and ends at 24:00, the voltage or ambient RF power level at the antenna increased and fell and then increased slightly in the 24-hour period. This wavelike variation typically occurs on a daily basis and is caused by tides: the peaks occurring at low tide when the effective ground plane provided by the water drops and the troughs occurring at high tide when the ground plane rises.

On Apr. 20, from about 8:00 to about 12:00, a sharp and constant-level dip in the ambient rf power occurred, as indicated. The magnitude of this pronounced dip is far greater than the normal tide-caused variations, as is its beginning and ending slope.

Thereafter, from Apr. 20 to Apr. 23, the plot (not shown) continued unremarkably, albeit with a slight variation from normal.

The same occurred on Apr. 24, with the plot actually being generally similar to a normal day. However at 13:15 on Apr. 24, as indicated, a large, Richter magnitude 6.0 quake occurred near Hollister, Calif., about 340 km away from the antenna. No change in the plot occurred at this time.

Correlation of this quake with the plot's marked dip of Apr. 20 was made by the repeated observation of dozens of similar dips and subsequent quakes. Pronounced dips were always followed by a quake several days later. Thus we have empirically established causal and theoretical connections between pronounced dips of the type shown and the occurrence of subsequent seismic activity.

Figure 3: Ambient Power Module

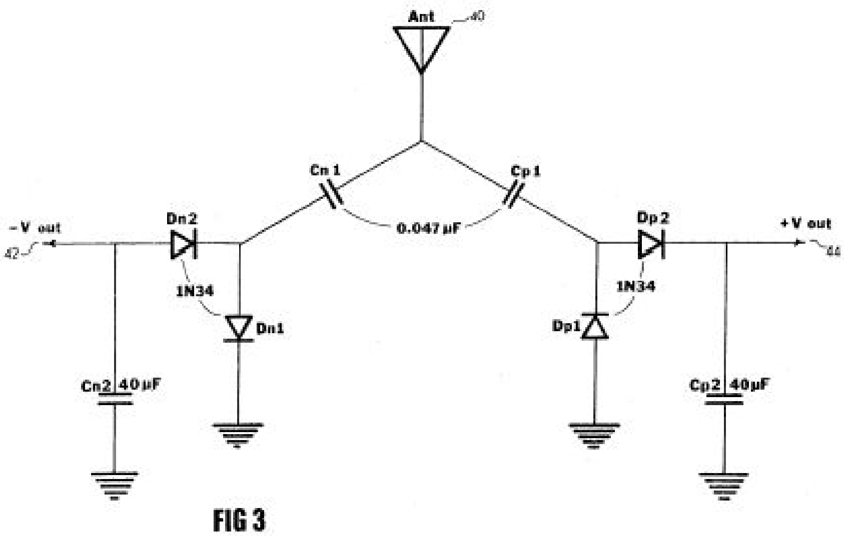


FIG 3

The circuit of Figure 3 is used to convert the ambient RF energy to a direct voltage which can be used and handled by data processing equipment. Designated an ambient power module (APM), it is connected to an antenna 40, preferably a broadband monopole antenna of the type described in the preceeding section. The distal end of the antenna is free and its proximal end is connected to the circuit via two capacitors Cp1 and Cn1, each being in series with the signal line for coupling and each having a value of 0.047 microfarad. Taking the left or negative side of the circuit first, it

comprises two rectifiers (diodes) Dn1 and Dn2 (1N34 type) and a filter capacitor Cn2 (40 microfarads). Rectifier Dn1 is connected in parallel to the signal path and rectifier Dn2 is connected in series, in the well known voltage multiplier arrangement. Capacitor Cn2 is connected in parallel across the output of the APM to smooth the rectified output. The right or positive side of the circuit is similar, except for the polarity of the diodes.

In operation, an RF voltage is developed across antenna 40; this voltage is voltage multiplied by the two rectifiers on each side of the circuit. The resultant direct voltages are smoothed or filtered by capacitors Cn1 and Cp2 and are supplied to output terminals 42 and 44. A positive version of this direct voltage is plotted in Figure 2, as described above.

Figure 4: Block Diagram of Computer

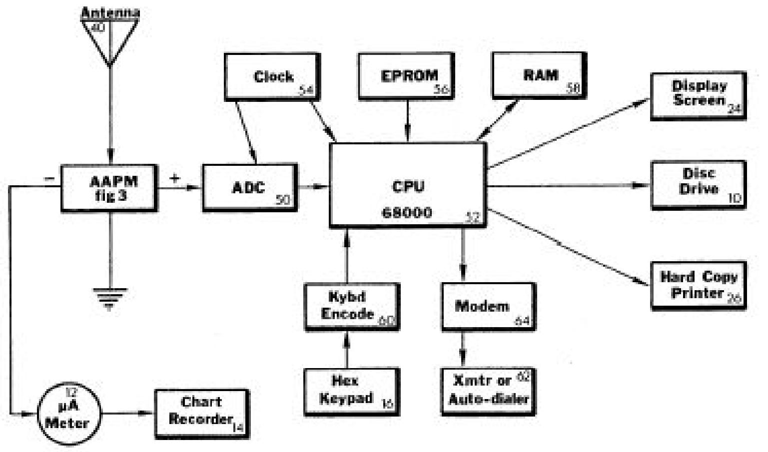


FIG 4

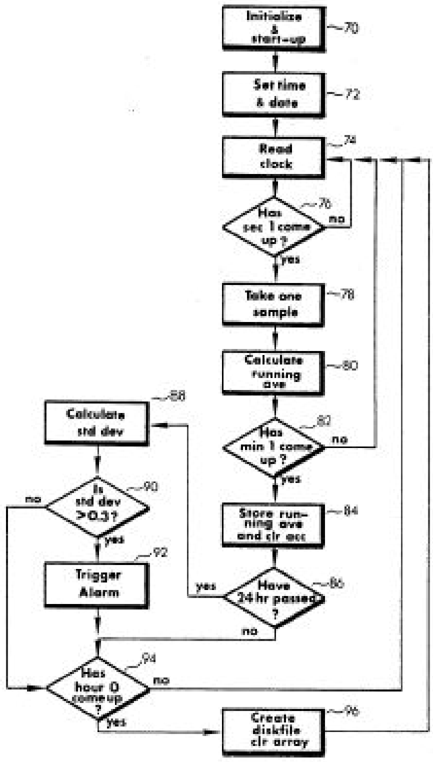
A computer for performing the monitoring and alarm functions of the invention and which is provided within the apparatus of Figure 1 is shown in Figure 4. The computer receives the positive voltage from the APM (Figure 3) and processes this, providing an alarm if the voltage dips a predetermined amount from its recent average value.
The computer comprises an analog to digital converter (ADC) 50 which is arranged to convert the positive DC voltage from the AAPM to digital form, preferably in the form of a parallel signal at the output of ADC 50. The digitized voltage from ADC 50 is supplied to a central processing unit 52, which is a type 68000 microprocessor or computer on a chip. CPU 52 and ADC 50 are clocked by a clock 54 in conventional fashion.

CPU 52 operates on instructions from a program contained in an electrically programmed read only memory (EPROM), the program being listed later. CPU 52 temporarily stores data in a read and write memory (RAM) 58. CPU 52 also supplies output data to display screen 24, disc drive 10, and hard-copy printer 26', each of which was already described in conjunction with Figure 1.

CPU 52 can receive input data manually from hexidecimal keypad 16 (see FIG. 1) via a keyboard encoder 60.
CPU 52 can supply an alarm output to a radio transmitter or automatic telephone dialer 62 via a modem (modulator-demodulator) 64 for connecting the CPU to a phone (not shown).

As also indicated in Figure 4, the negative output of the AAPM of Figure 3 is connected to ammeter 12 and chart recorder 14.

Figure 5: Flowchart of Seismic Early Warning System



In operation, the system of Figure 4 operates under control of the program in EPROM 56 in accordance with the flowchart of Figure 5 as follows:

Startup: Blocks 70 and 72: An initialization and start-up sequence is first initiated when the machine is turned on, as indicated by block 70; this sets all registers and counters to zero. The time and data are then set manually (using EPROM 56), as indicated by block 72.

Clock Reading: Blocks 74 and 76: Next, under automatic program control, the machine reads the elapsed time on its clock display register, as indicated by block 74. If the "seconds" register does not indicate the number one (#1), the machine continues to read the clock, as indicated by the "no" output of decision block 76.

Minute Sample: Block 78: When second #1 appears, as it will once per minute, the decision in block 76 will be "yes", so that the machine will take one sample of the rectified, smoothed, and digitized version of the antenna's output, i.e., the output of ADC 50 of Figure 4, as indicated in block 78. This sample will be taken once per minute, i.e., whenever second #1 is displayed.

Running Average: Block 80: Next, as indicated by block 80, a running average of the samples taken in block 78 is calculated. This is done by accumulating the samples to keep a running total of their values, counting the number of samples accumulated, and dividing the running total by the latest number of samples each time a new sample is taken.

Store Hourly Average: Blocks 82 and 84: Next, as indicated in block 82, a test is made to see if the time display register indicates that minute number one (#1) has come up. If not, the decision is "no" and the clock is read again (block 74). If the decision is "yes", as it will be once per hour, the running average in the accumulator will be stored (block 84) and the accumulator will be cleared or reset to zero.

One Day Test: Block 86 ("No" decision) and Block 94: Next the machine makes a test to see if 24 hours have passed. If not, the machine will not be able to make any valid statistical determinations. Thus it must run at least 24 hours before being operative. Assuming the decision in block 86 is

negative (24 hours have not yet elapsed) another test is made (block 94) to see if hour zero is indicated, which will occur once per day. If hour zero is not indicated, (decision in block 94 is negative), the clock will be read again (block 74) in the usual loop.

Calculate SD: Block 86 ("Yes") and Block 88: If a full day has elapsed, so that valid statistics can be calculated ("yes" from block 86), the standard deviation (SD) of the last 24 hourly averages is calculated, as indicated in block 88. This is done once per hour. The calculation is made using the usual SD formula

SDDEV=SQR([sum(x-X).sup.2]/n)

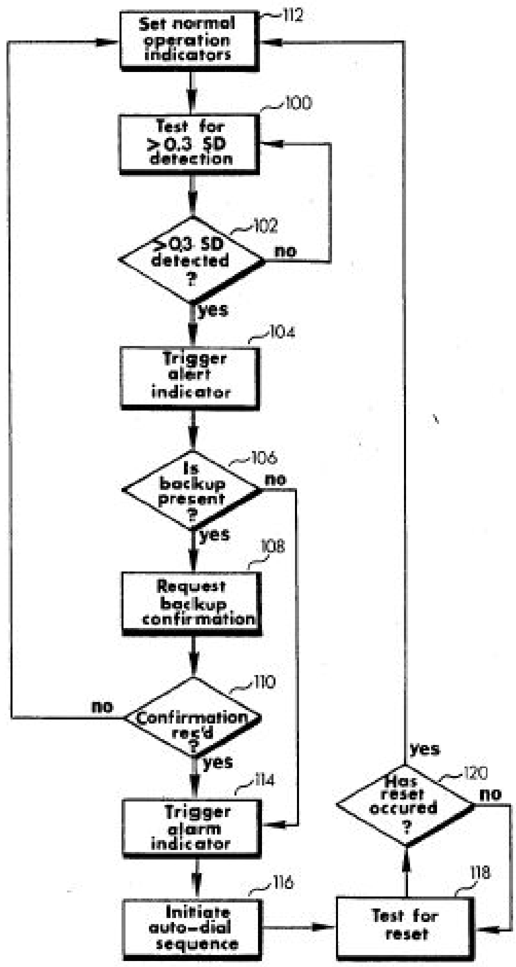
where SDDEV=SD; SQR=the square root; sum=the sum of; x=the individual hourly averages; X=the mean of the hourly averages; and n=the number of individual hourly averages. Essentially the SD is calculated by taking the mean of all of the hourly averages, taking the difference or deviation of each hourly average from the mean, squaring each deviation, taking the mean of the squared deviations, and then taking the square root of the mean of the squared deviations.

Evaluate SD: Block 90: The SD is then evaluated to see if it is greater than 0.3. This value has been empirically determined to be the level at which the present apparatus will provide a reasonably positive indication that an earthquake will occur, while neglecting the effects of non-seismic-caused variations. If the SD is less than 0.3, (a "no" output from block 90), this indicates that the last hourly average was not greatly different from the average of the last 24 hourly samples, so that no alarm need be indicated. I.e., the antenna's output did not drop significantly to indicate an impending earthquake. Thereupon the program moves to block 94, where a test is made for the existence of hour zero, as described. If, however the SD exceeds 0.3 ("yes" output of block 90), this indicates that the antenna's output has dropped significantly so as to affect the last hourly average, thereby to indicate an impending earthquake.

Alarm: Block 92: In response to the Yes output of block 92, an alarm is triggered (block 94). The alarm may be a bell, the dialing of a telephone to a location where personnel are present if the apparatus is placed at a remote or non-manned location, or the initiation of the further program of the Flowchart of Figure 6, the alarm trigger sequence. To eliminate the possibility of equipment failure and to provide confirmation from another apparatus at another location, we prefer to provide an alarm only upon confirmation from another apparatus, as discussed in the description of Figure 6 below.

Make Record: Block 94 ("Yes") and Block 96: If hour zero is being displayed when the operation of block 94 is performed, which occurs once per day at midnight, the operation of block 96 will be performed, i.e., the data in the registers will be stored to disc to create a permanent record and the registers will be cleared to create new data for the next day. However the previous 24 hourly averages are still stored at all times so that a valid SD can be calculated and tested every hour. After the operation of block 96, the clock is read again in accordance with the regular program (block 74).

Figure 6: Alarm Trigger Flowchart



The sequence of Figure 6 is performed when the alarm is triggered in block 92 of Figure 5 as an optional, but preferred backup confirmation of an impending earthquake. The operations in the backup confirmation system will be described briefly.

Beginning with blocks 100 and 102, the system is continually tested (hourly) for the occurrence of a SD of the hourly averages of greater than 0.3. If the SD is greater than 0.3, the alert indicator (28 of Figure 1) is triggered (block 104) and the program initiates a test (block 106) to see if a backup apparatus (not shown) is present. If so (yes output of block 106) the backup apparatus is also checked (blocks 108 and 110). If the backup does not indicate an excess SD, the indicators are reset to normal (block 112), but if backup confirmation is received, the alarm indicator (30 of Figure 1) is triggered per block 114 and a preprogrammed telephone number is dialed and indicator 32 is lit (block 116).

After the alarm condition is manually checked and the system is reset, the output of block 120 will be a "yes" and the system will be reset to normal (block 112). If a valid alarm condition is indicated and confirmed, civil authorities will have time (usually several days) to notify the populace, evacuate the area, or take any other needed precautions, depending on the size of the impending quake as indicated by the size of the standard deviation.

Programs

The attached computer programs will perform the calculations and operations above described. These programs are written in the BASIC programming language. Program "RECVOLT.AL" runs continuously and writes the information to disc every 24 hours. Program "GRASTAT.*" is manually run; it reads data from the disc and plots it on the screen or printer, as desired.

While the above description contains many specifications, these should not be construed as limitations on the scope of the invention, but merely as an exemplification of one preferred embodiment thereof. Many other variations are possible. For example, the programming language can be changed, or the calculations and operations can be performed with hard-wired conventional circuitry in lieu of a programmed computer. More than two corroboration receivers can be used, and these can be placed at various locations. In lieu of testing the antenna's output reception of the area's AM stations, a special, dedicated transmitter with a special, dedicated frequency and a specially-tuned matching receiver can be used to avoid dependence on stations which are not under the control of the earthquake prediction system and its personnel. The transmitter and the receiver should be spaced apart geographically, preferably by at least several km, so that the ground plane conduction phenemonon can operate. Also the transmitted signal can be a specially-coded or modulated signal, or it can be an auxiliary signal of a regular transmitter, e.g., a SSB or SCA signal, together with a matching receiver. In lieu of a test for an excess SD, the apparatus can be arranged to test for a predetermined drop in the value of the antenna output from its immediately previous value or its average value over a predetermined period, such as an hour or day, or for a drop having greater than a predetermined slope. Accordingly the full scope of the invention should be determined by the appended claims and their legal equivalents, and not by the examples given.

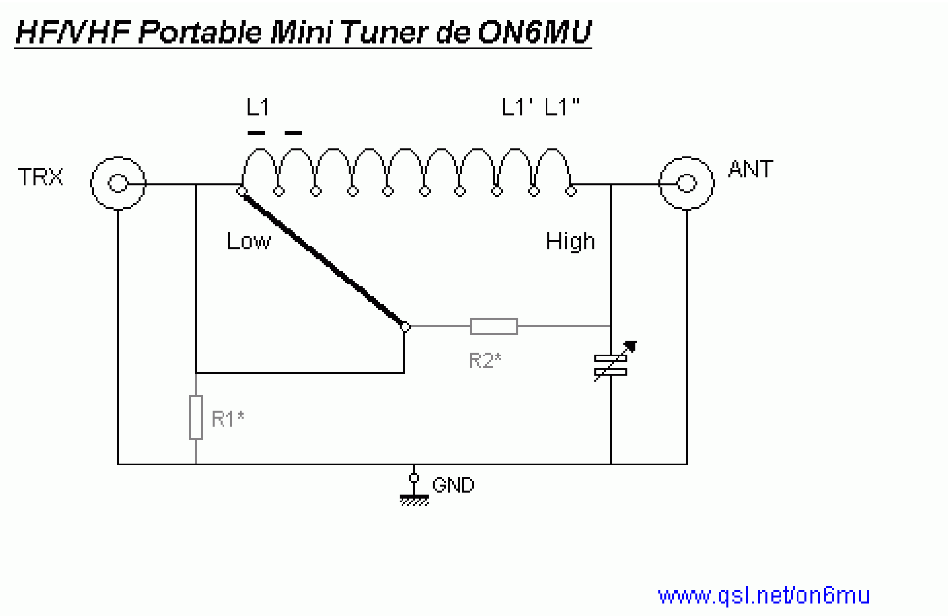
Claims -- [Not included here]

ON6MU

HF/VHF Portable Mini Tuner
RE-AT2HF6/P

By Guy, de ON6MU

Schematic fig1



RE-AT2HF6/P Parts list

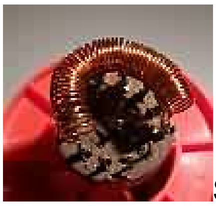
- alu box of 70mm X 40mm X 33mm
- 2 female PL 259 chassis
- C1 = variable capacitor of at least 300pF or better 500 pF
- S1 = 10 or more position rotary switch
- L1 = 0,7mm insulated copper wire, 6 turns par connection closely together, 9mm outside diameter (8mm inside)
  taps every 6 turns and the last two sections (L1' and L1") 4 turns spaced at 1mm and 3turns spaced by 2 mm.
  The first two sections has a ferrite core inside.

Could be that lower frequencies needs higher inductance, experiment with by adding a core in the last few sections (see fig2)

- I added two bolts on the alu-box chassis to - if needed - connect the tuner to ground or for using a counterpoise.
- R1: 1.5k carbon 1/4w (non-inductive resistor); optional to allow drain of possible static build-up on the antenna (or use a 10mH inductor)
- R2: 2 x 470 carbon 1/2w parallel (non-inductive resistor); optional to have some little protection during switching when using a carier, as the switch could open the the connection for a fraction of a second during switching.

The coil

- Wind 6 turns x - 2 connections on your switch (in this project a 10-position rotary switch is used, being 8 times 6 = 48 + 4 + 3 = 55 turns) over a 7mm screwdriver (or simular obkject hi) and make a tap every connection. Solder each tap.

- Solder each tap to each connection of your switch and stretch L1' (being 4 turns) at 1mm spacing and L1''(being only 3 turns) at 2 mm spacing. You can replace L1'' by 3 turns of silver wire to allow better Q on higher frequencies (VHF).

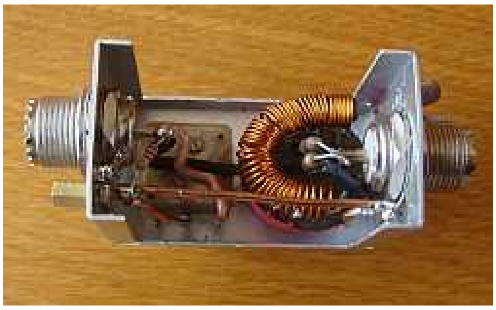
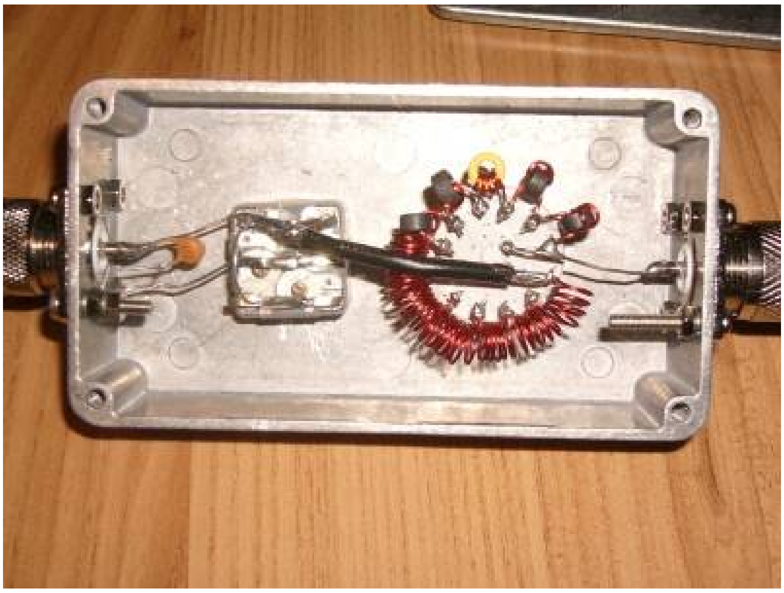
-  Minituner insides...

Fig.2

-  *Alex VE7DXW changed 5 of the lower 6 wdg air coils with 1 wdg, 2wdg, 4wdg, 4wdg, 6wdg ferrite core coils, which gives higher L values*
  Thanks Alex!

Specifications

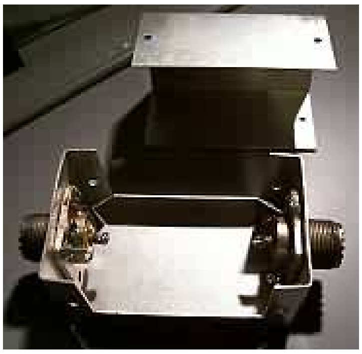
- manual operation
- frequency range (depending on the coil min & max inductance):
  160m...6m
  (Up to 150Mc if: L1" is silver(plated) wire, High Q switch, minimum capacitance of C is small enough and close connections are used in respect to 50 Ohms impedance)
- 10 Watt +-
- direct feed through
- small and compact design ideal for low power QRP transceivers, like the Yaesu FT-817, or of course for receivers...
- connection for counterpoise/ground

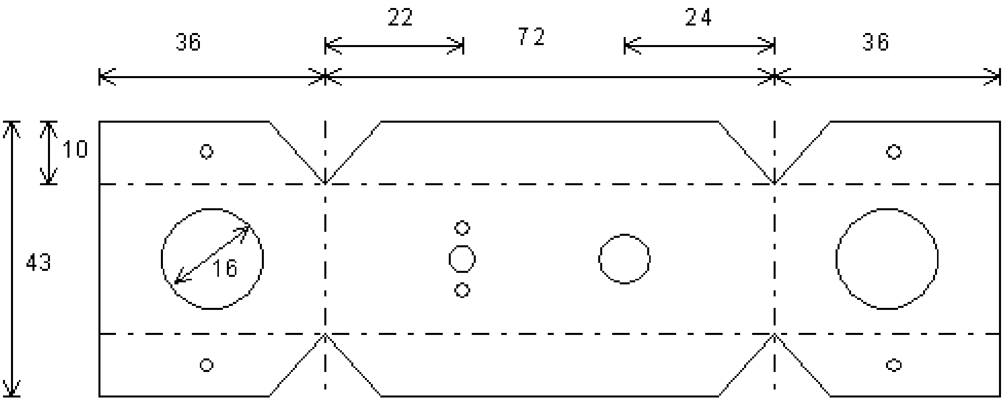
Notes:
If you elect to use an antenna tuner, it is extremely important that you understand exactly how to use tuners and what they can and cannot do. A few watts of RF can easily become lost in an incorrectly adjusted antenna matching device. The whole idea of a QRP station is to keep things simple and economical, so I cannot overemphasize the priority of a clean, efficient connection of the amplifier output to a resonant antenna.

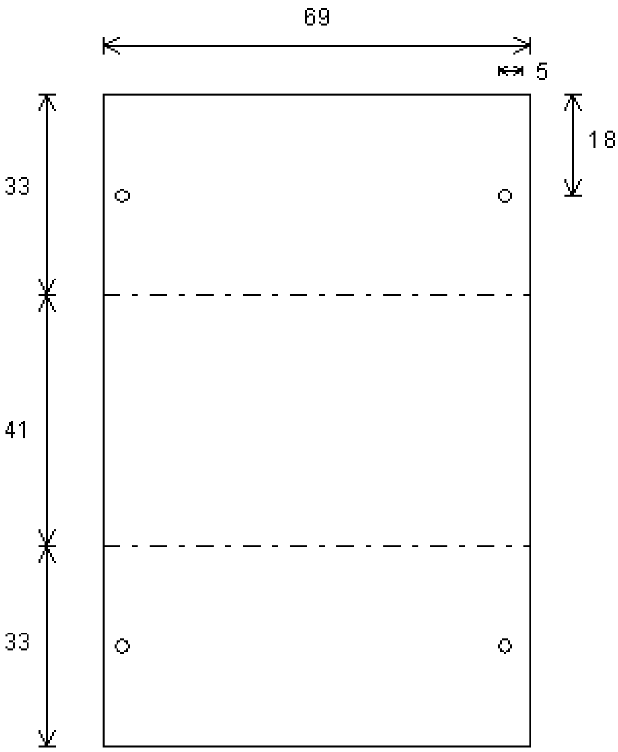
Don't forget to check these out:
ON6MU Homebrew projects
Radioamateur related projects

ON6MU Ham mods
Modifications of transceivers

Homemade aluminum box







73"

ON6MU
Home

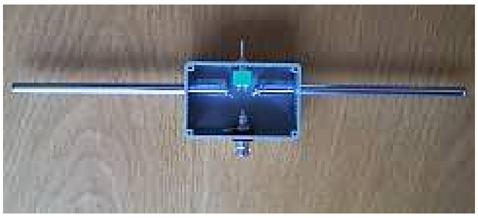
VHF/UHF Wideband Portable Dipole

RE-A6270D12P

ideal for the FT-817 etc.

By Guy, de ON6MU

I wanted a robust, portable, compact antenna usable for horizontal and vertical polarisation to take along with my FT-817 when I go on vacation, camping etc. I also wanted the dipole to cover the VHF and UHF bands and if possible with some gain! As everybody knows a dipole has about 3dB gain over a quartre wave antenna, is why my preference went to a simple dipole. To make it portable I used two identical telescopic antennas of 80 cm slid out and only 14 cm when pushed in.

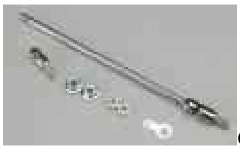


What you need to make this handy portable wide band dipole is:

- Two chrome-plated telescopic antenna's (14cm/80cm)
- A robust PVC box of 75x50x22 mm and 1,5mm thick
- a silver plated stereo mini switch
- a professional female BNC connector
- some low loss RG174 50 Ohm coax
- carbon/ferrite bead or toroid (to act as a shoke)
- some 0,6mm enamelled copper wire to make the coils (like from a transformer)
- a small ferrite core to place in L2 (approx 4 mm diameter)
- glue gun and/or silicone

 BNC  silver plated switch

 carbon based bead  RG174 thin low loss coax

 chrome telescopic antenna  ABS plastic anti-static box

I did not find a telecopic antenna small enough to reach 450 MHz and still long enough to reach 50 Mhz (1,5 meter), so the only sollution was to tune the dipole (made out of two 80 cm telecopic antennas) for 50Mhz using two coils (base loaded dipole). A double silver plated switch is used to shorten the coils when using it for frequencies above 50 Mhz. The gain when using the coils (loaded dipole to get a shortened dipole) on 50Mhz is approx. the same as a quartre wave, meaning no gain.

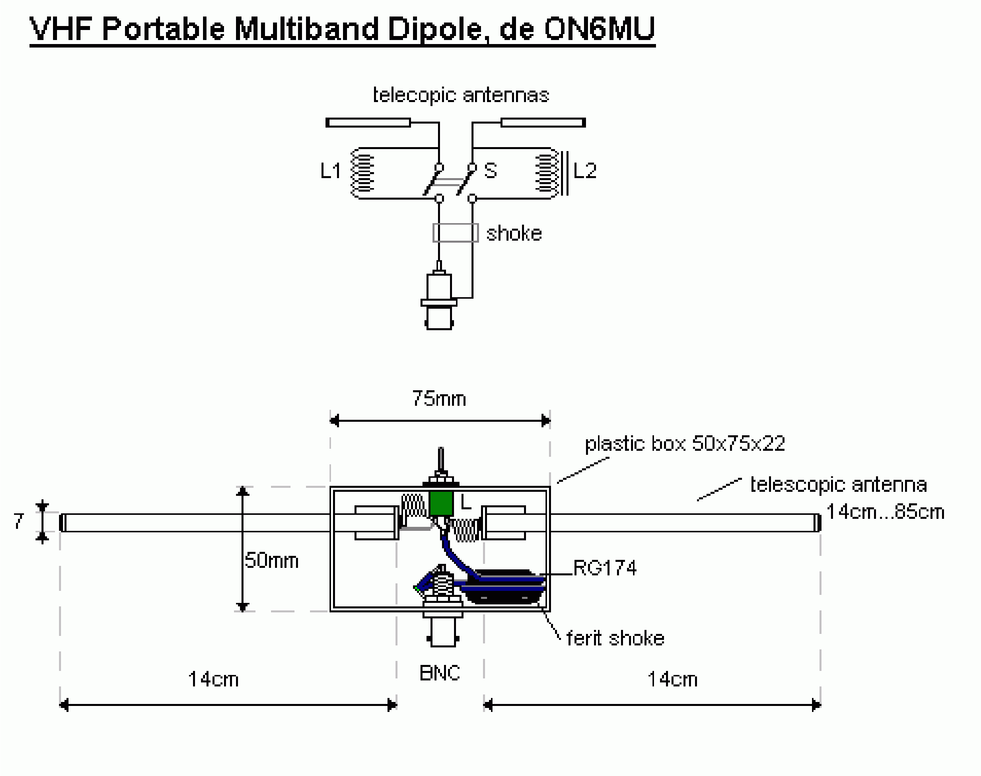
You can use any size of telecopic antenna, but just beware that the minimum length determines the highest frequency and the maximum length of the telescopic antenna determines the lowest usable frequency!
In my case, using a 14cm/80cm telescopic antenna, I calculated the working frequency range:

- 90MHz to 470MHz (switch closed)
- 48MHz to 90MHz (switch open)

You can tune the dipole to the desired frequency by sliding both telescopic antennas in or out.

This little antenna could also be used for satellite as the dipole tuned to 145 MHz works reasonable well on RX @ 435 MHz.

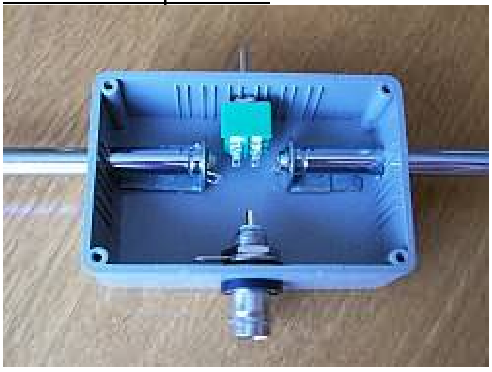
Links of interest:



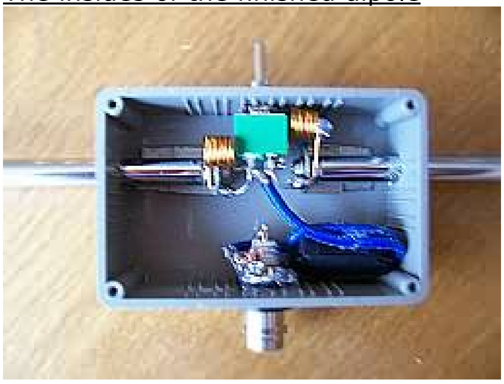
The coils

We need two pieces of emalled 0,6mm copper wire (stripped from a transformer will do). Wind the wire around a 5,5 mm drill till you get 8 turns. Both coils are exactly the same with one exception: in the coil mounted on the ground side (L2) we put a little ferite core inside the coil and seal it with some glue. When the switch S is open they will allow you to use the dipole on 50Mhz when both telescopic antenna's are in full length (2 x 80 cm).

Inside the dipole box



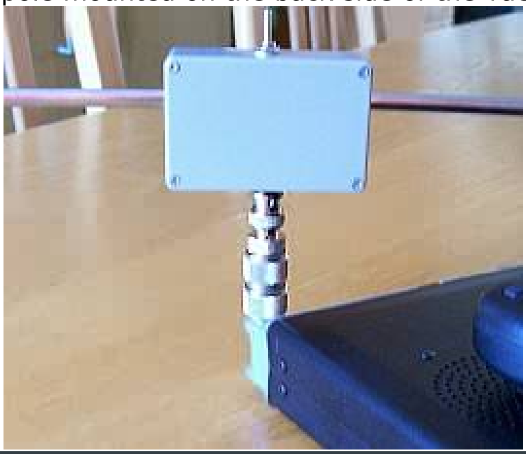
The insides of the finished dipole



After you tested the dipole you can finish it by using your glue gun tor silicone) to seal everything up.

The maximum TX power is approx. 10 watt.

Finished dipole mounted on the back side of the Yaesu FT-817



Jeff, AJ8P sent me a few pictures:

....

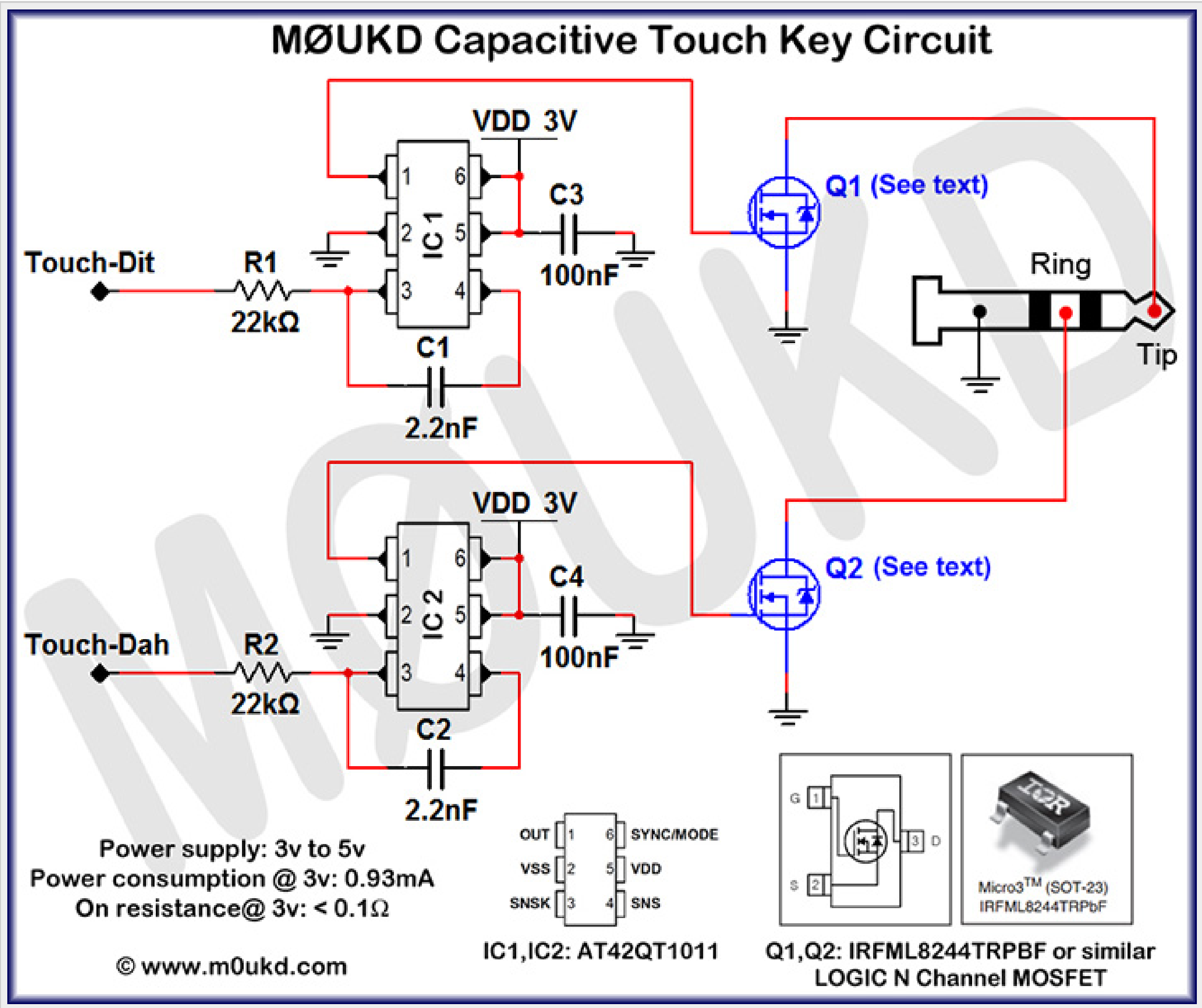
..  ..

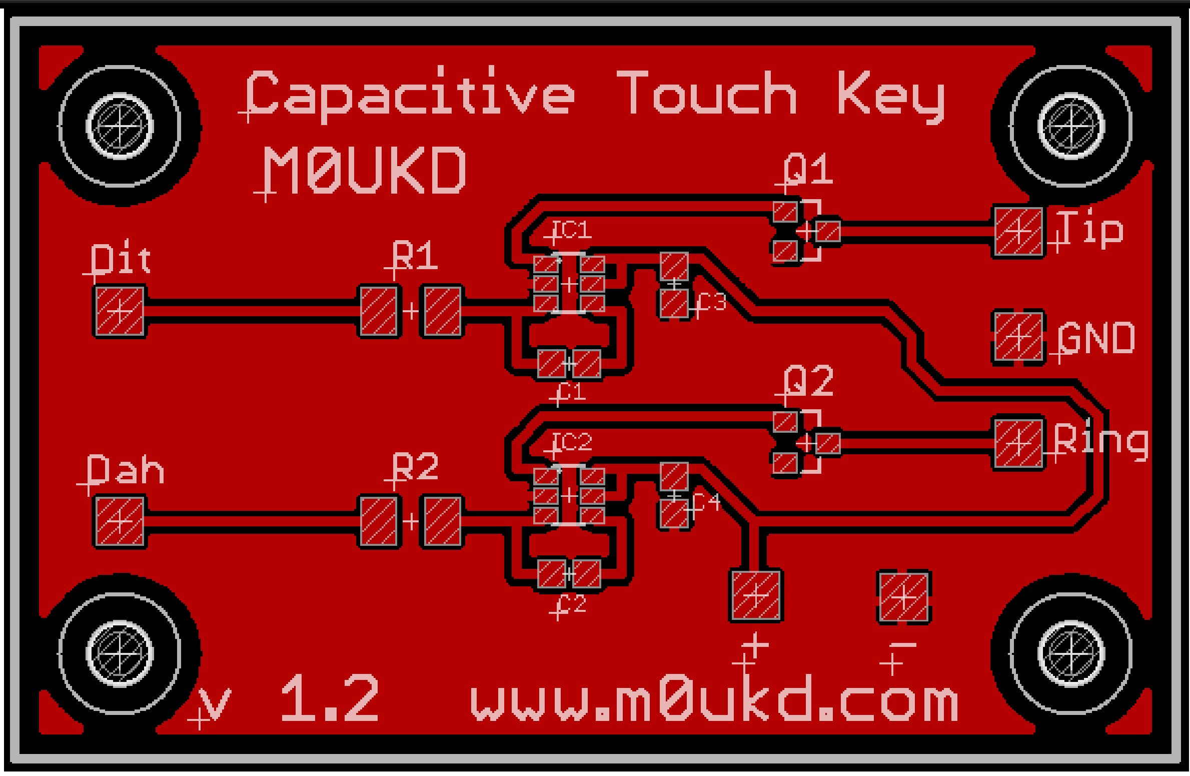
Thanks Jeff!!

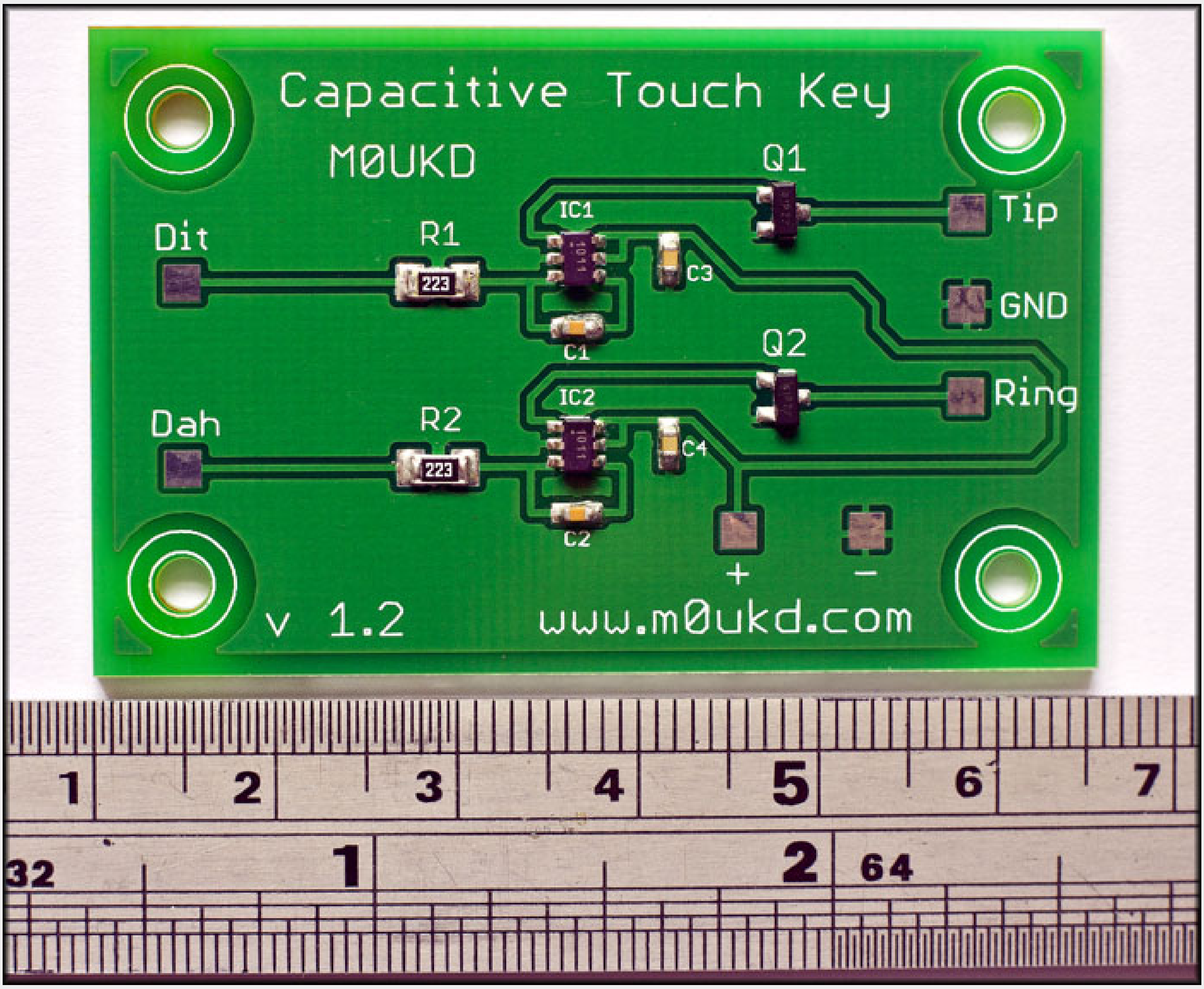
Home
www.qsl.net/on6mu

ON6MU

Capacitive CW Touch Key Circuits




Capacitive Touch Key
M0UKD
Q1
IC1
Tip
Dit
R1
C3
GND
C1
Q2
IC2
Ring
Dah
R2
C4
C2
+
-
v 1.2
www.m0ukd.com


Capacitive Touch Key
M0UKD
Q1
IC1
Tip
Dit
R1
223
C3
GND
C1
Q2
Ring
IC2
Dah
R2
223
C4
C2
+
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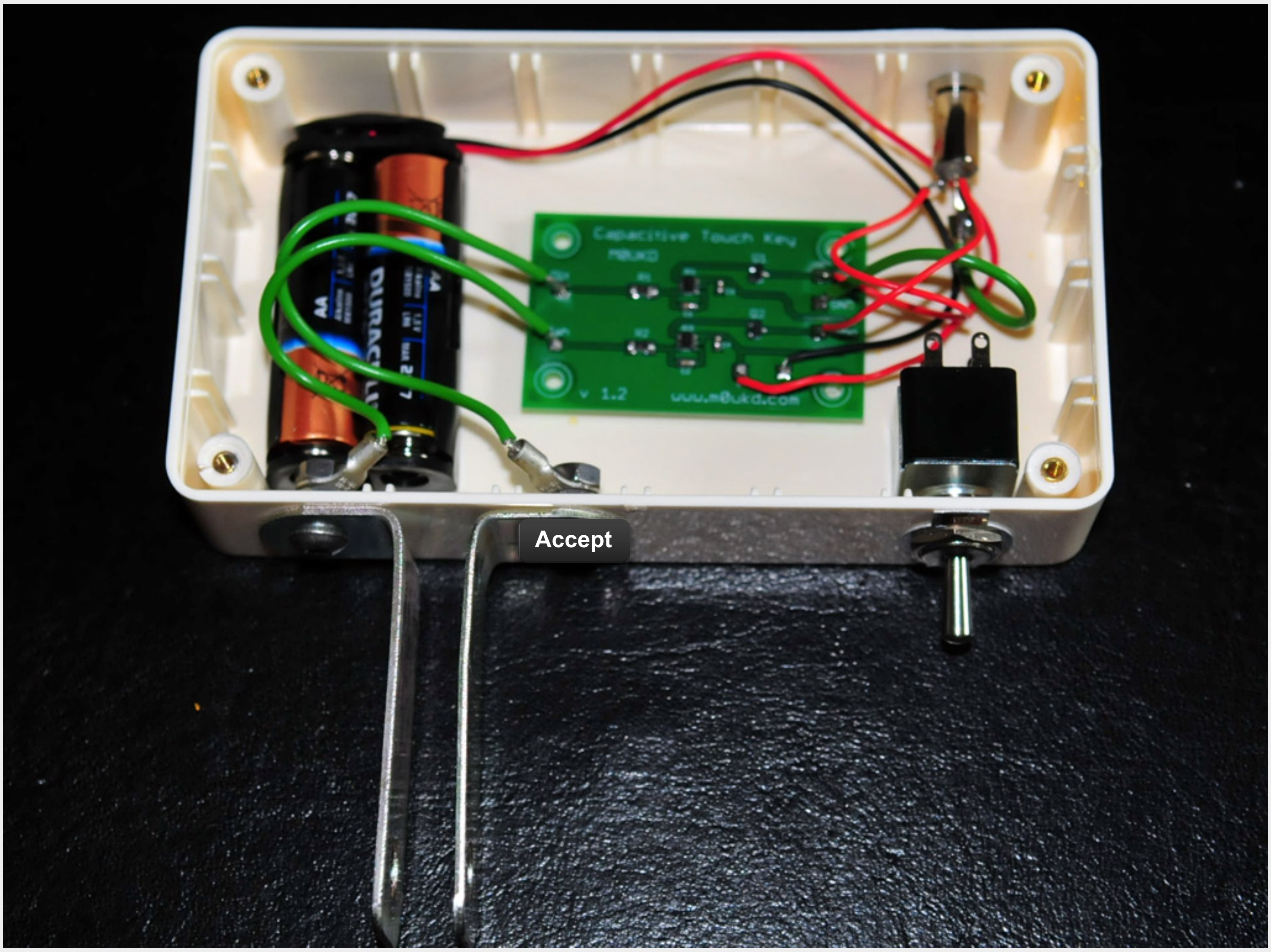
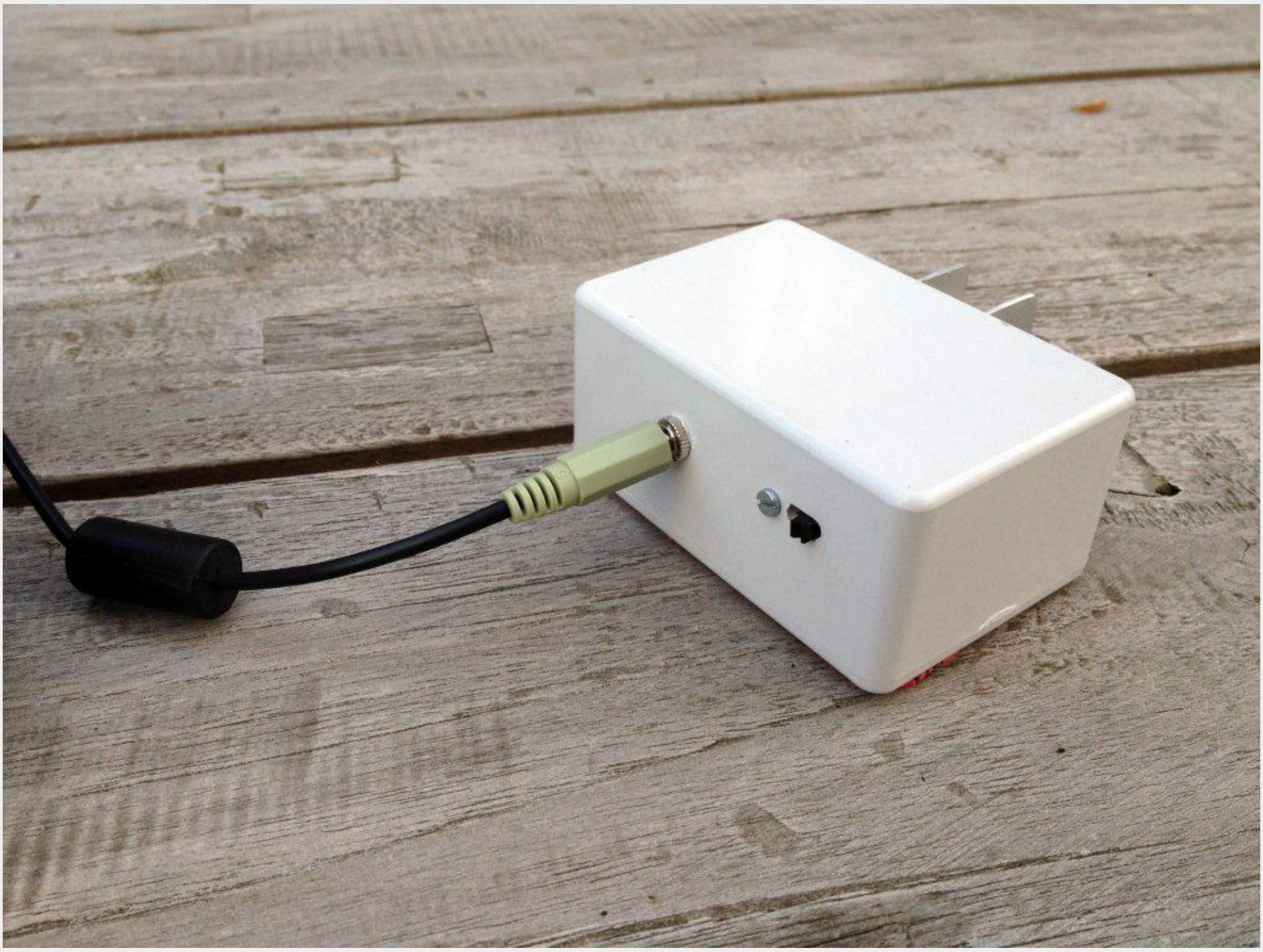
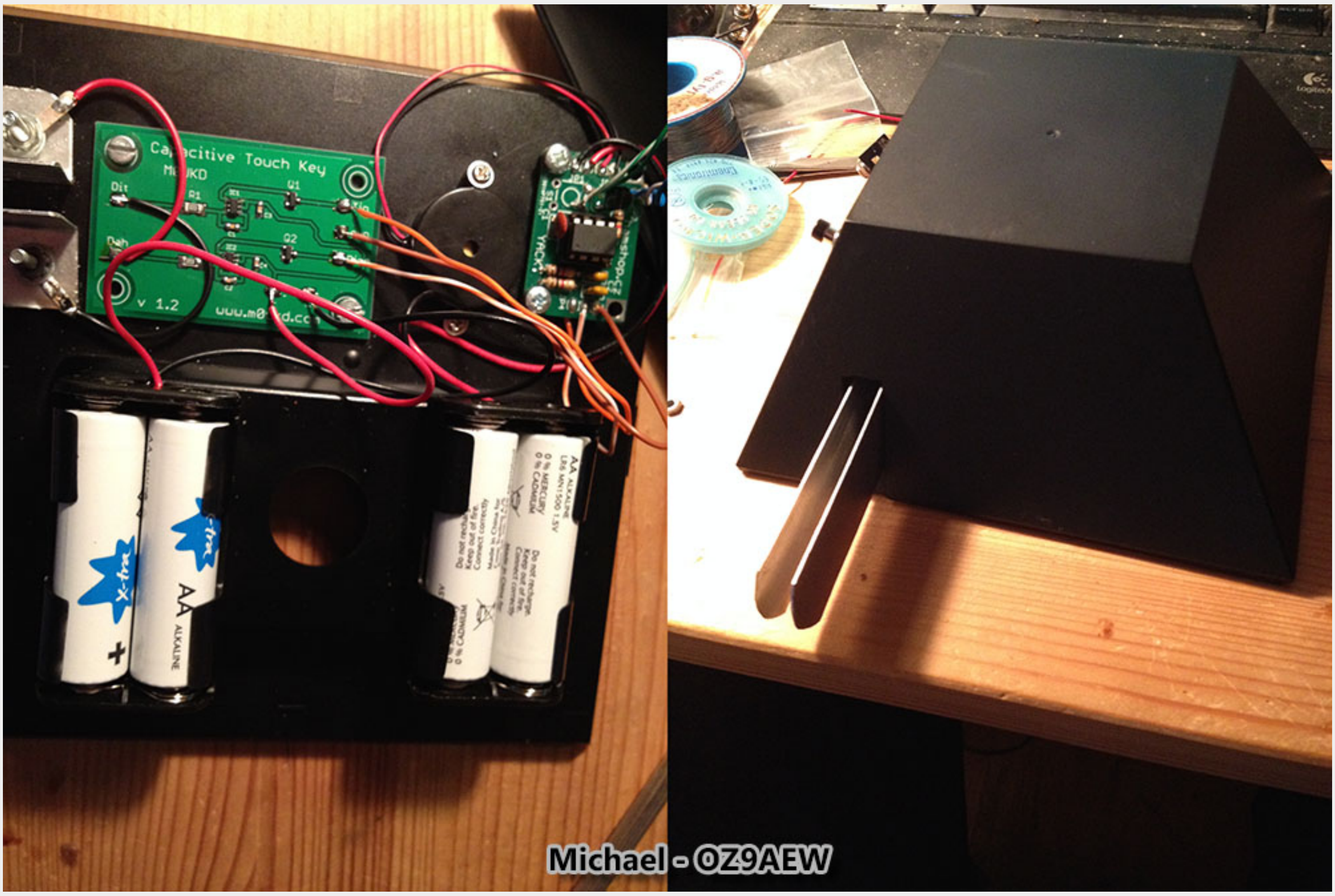
www.m0ukd.com



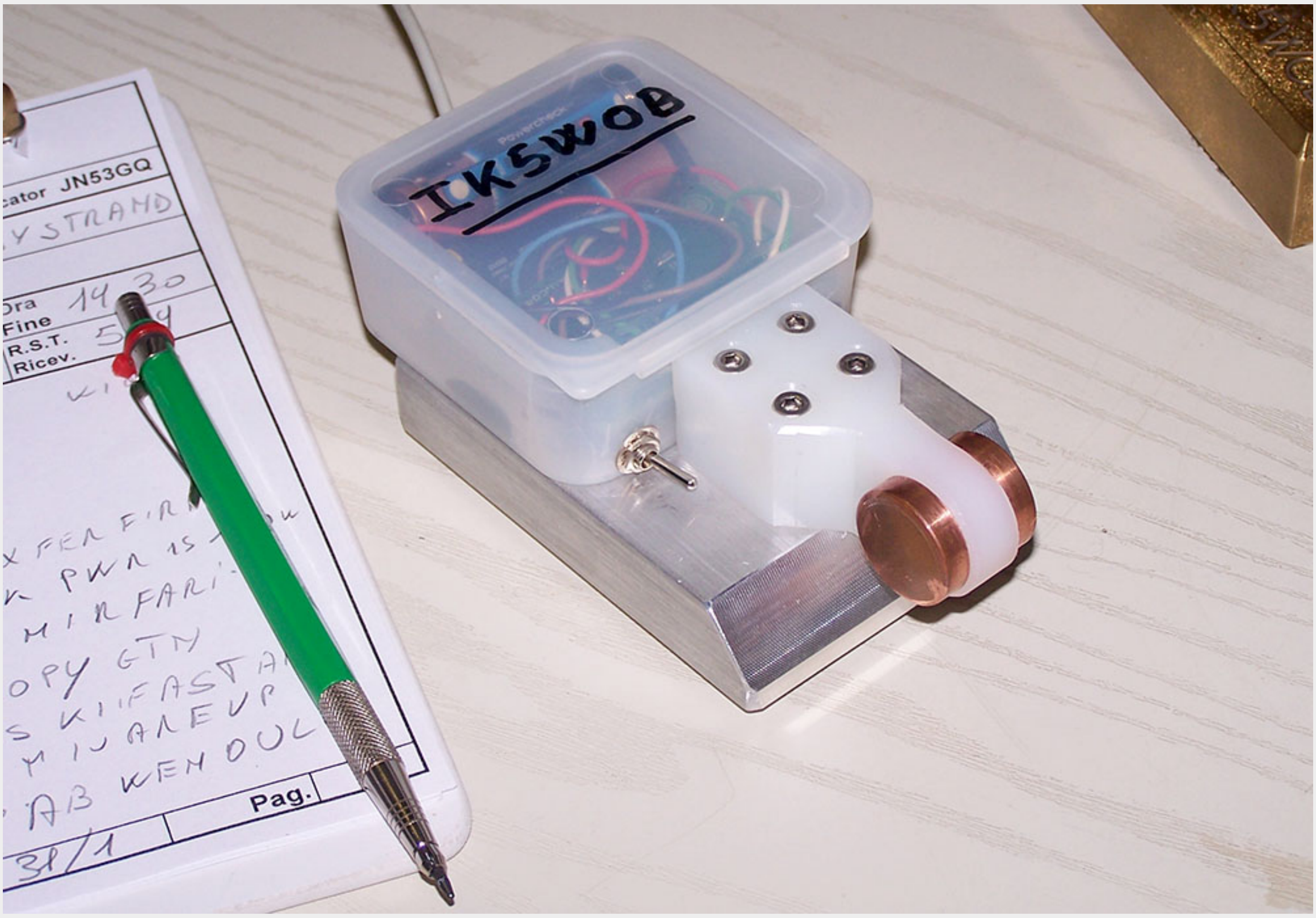
Accept

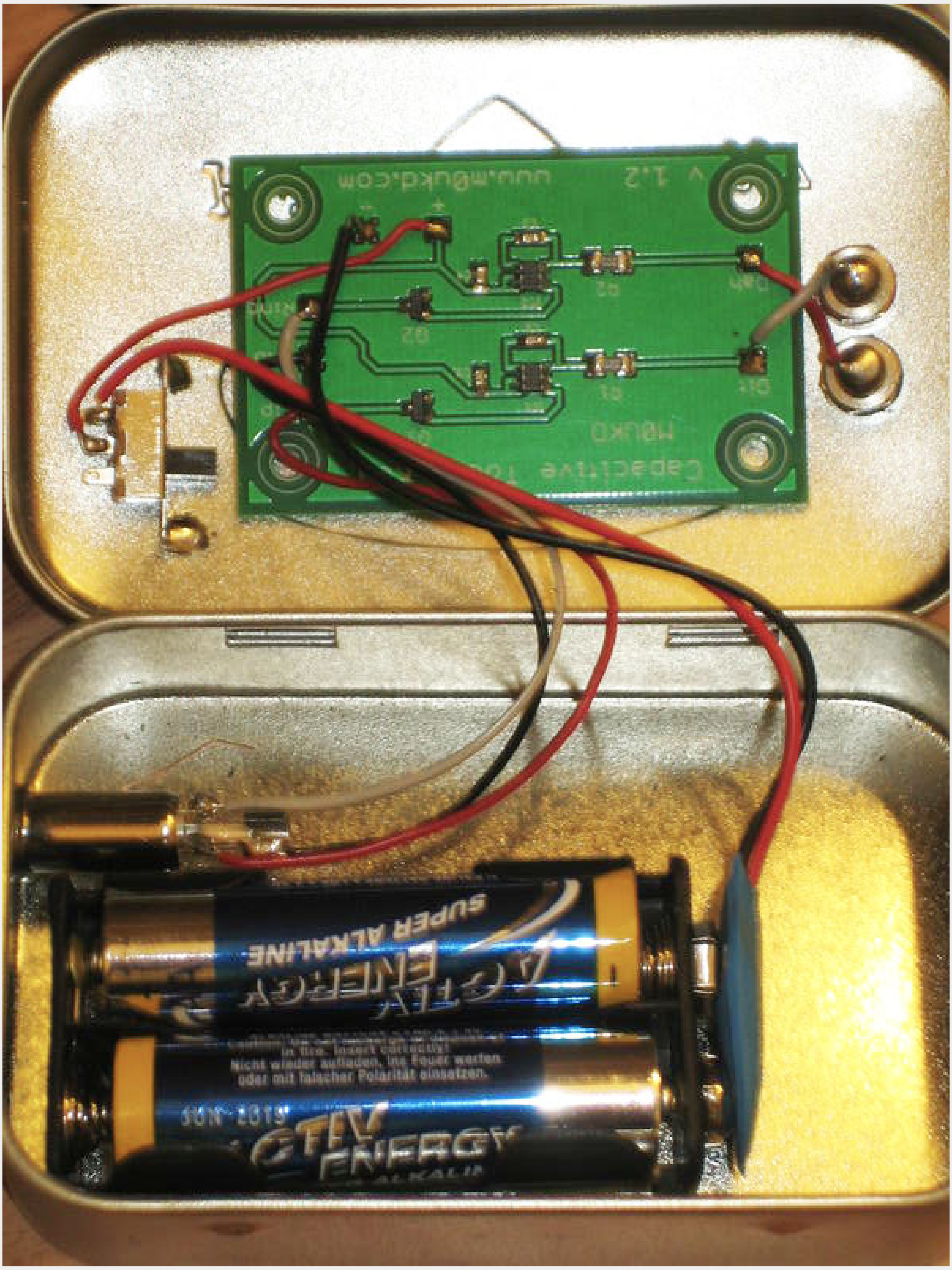



ELECRAFT
K1 TRANSCEIVER
BAND
DISPLAY
MENU
EDIT
AF GAIN
RIT / XIT
ATTN
WPM +
XFIL
WPM -
RIT
XIT [PFn]
TX
RX


Capacitive Touch Key
M0UKD
v 1.2
Michael - OZ9AEW

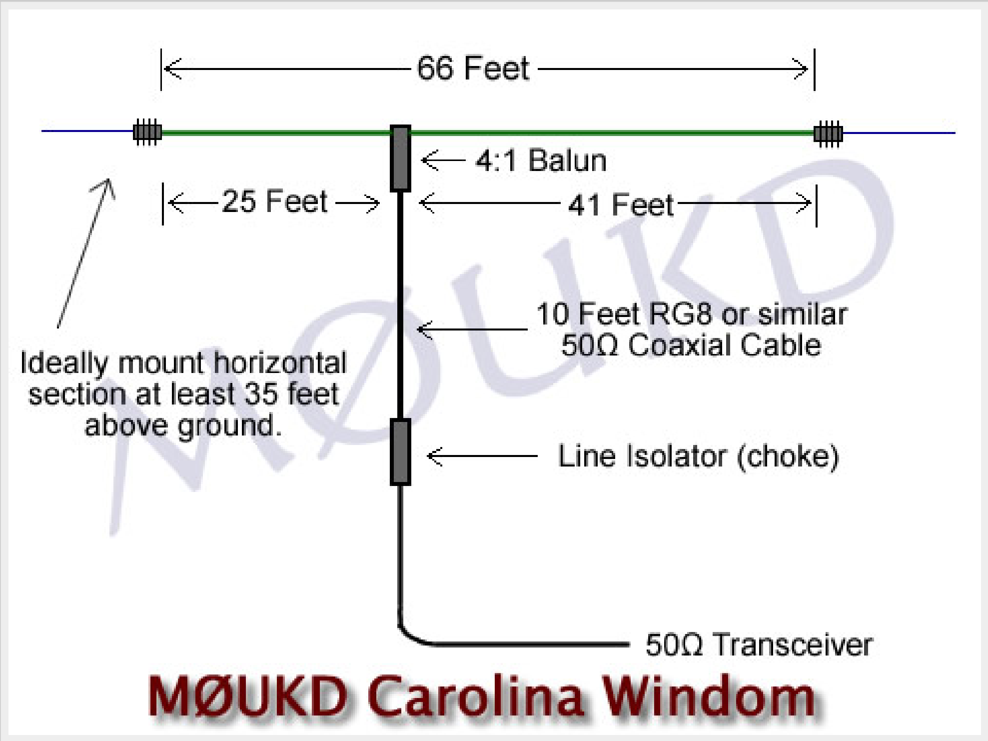

BARKLEYS
IK5XCT TOUCH PADDLE
CINNAMON
IK5XCT TOUCH
November 2014
IK5XCT PROJECT

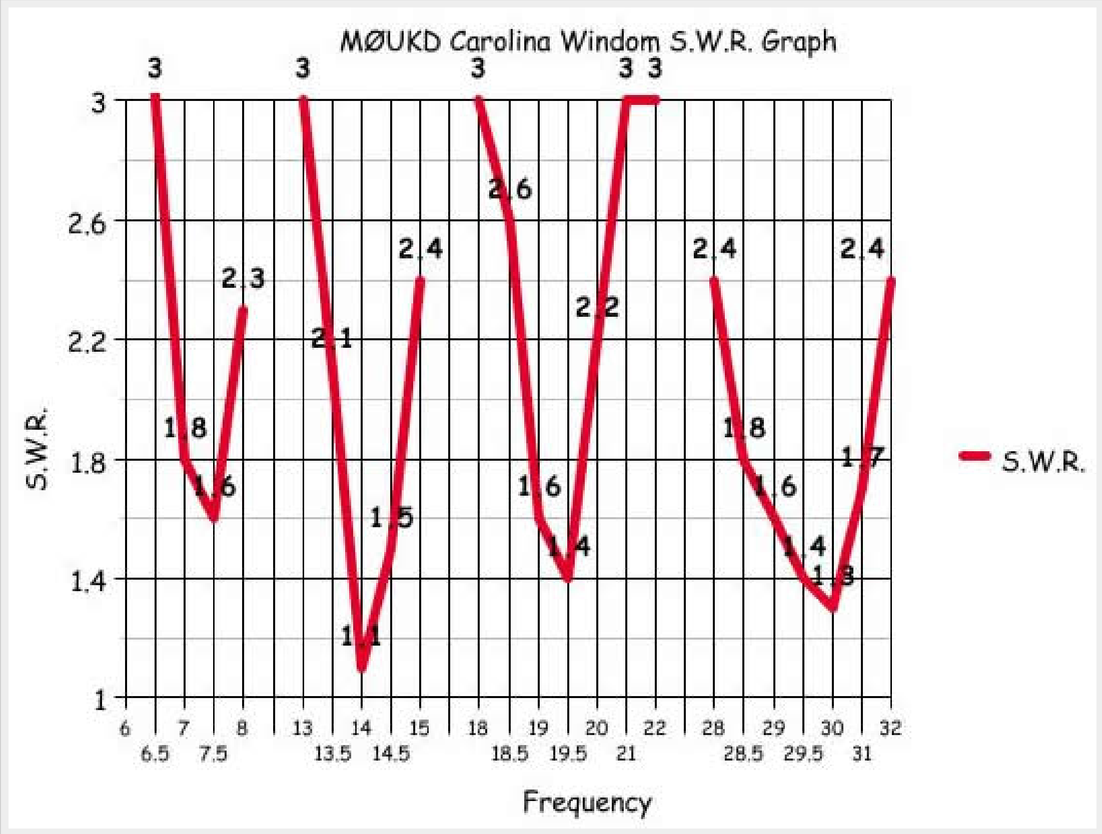

IK5WOB
cator JN53GQ
Ora
Fine
R.S.T.
Ricev.
Pag.


www.m0ukd.com
v 1.2
M0UKD
SUPER ALKALINE
ACTIV ENERGY
Nicht wieder aufladen, ins Feuer werfen
oder mit falscher Polarität einsetzen.


Capacitive Touch Key
www.m0ukd.com
Off

Homemade Carolina Windom antenna




MØUKD Carolina Windom S.W.R. Graph
S.W.R.
Frequency
3
2.6
2.2
1.8
1.4
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6
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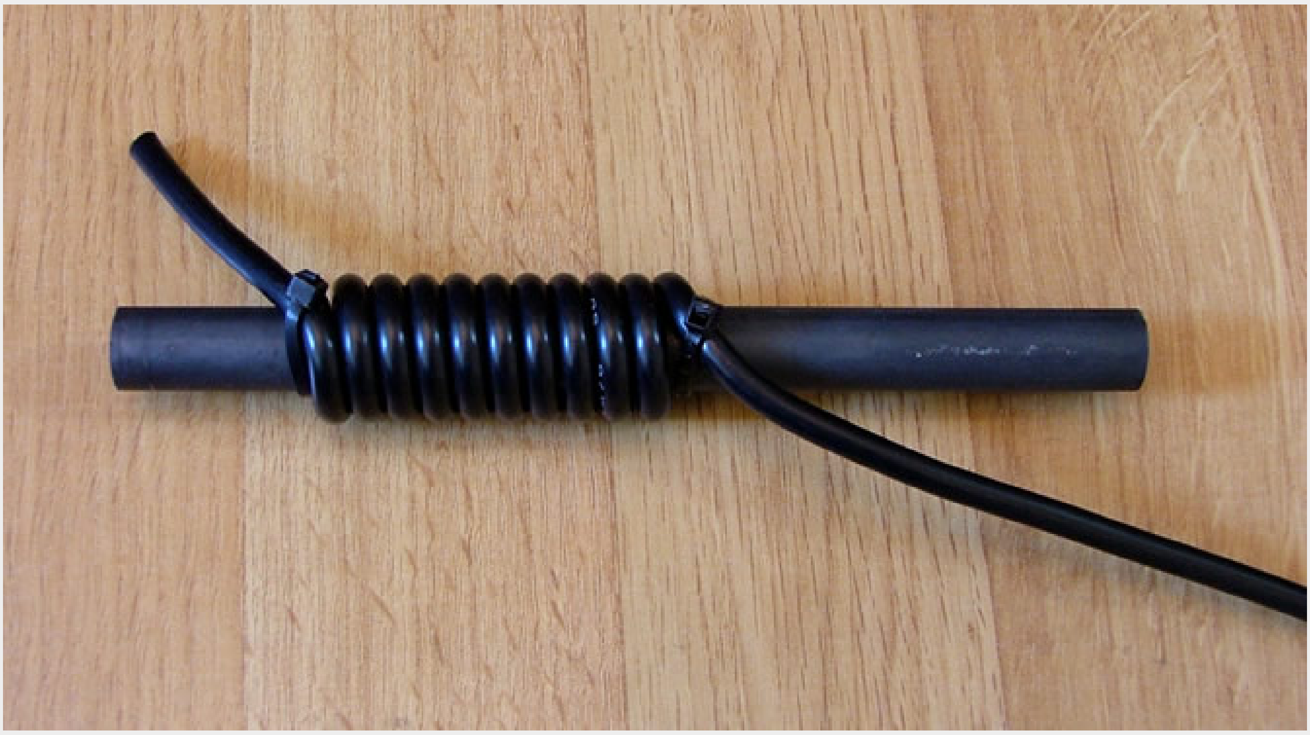
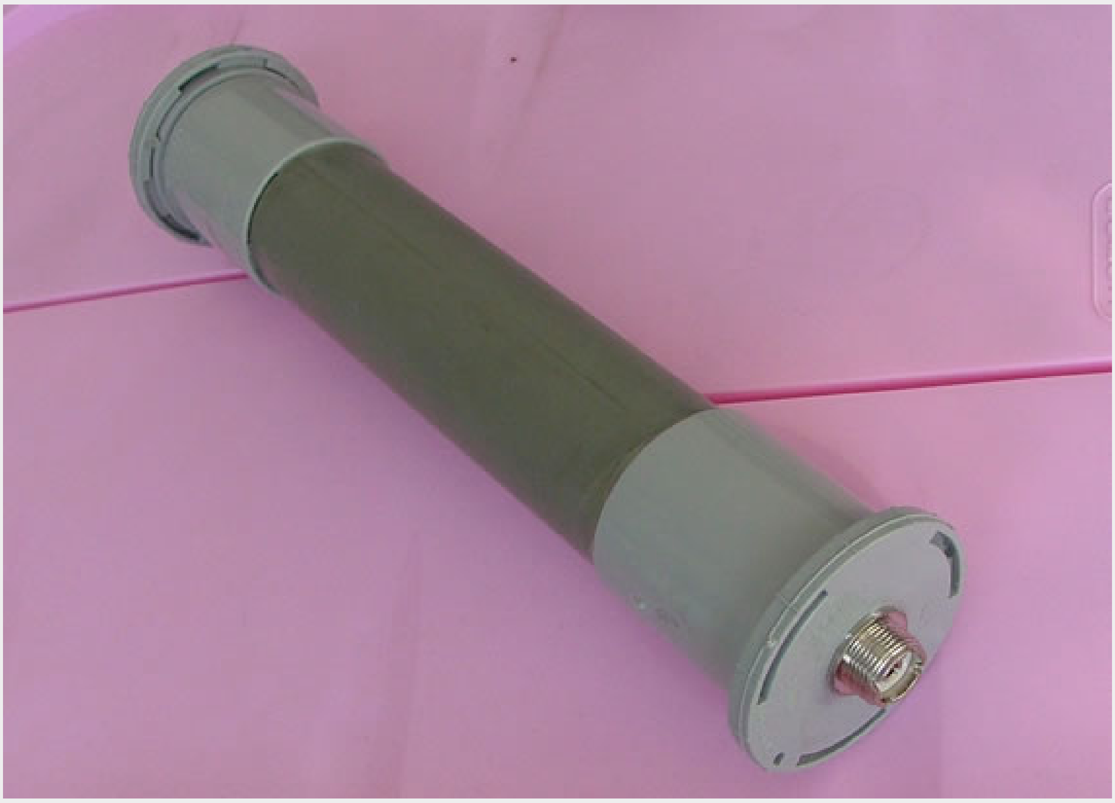
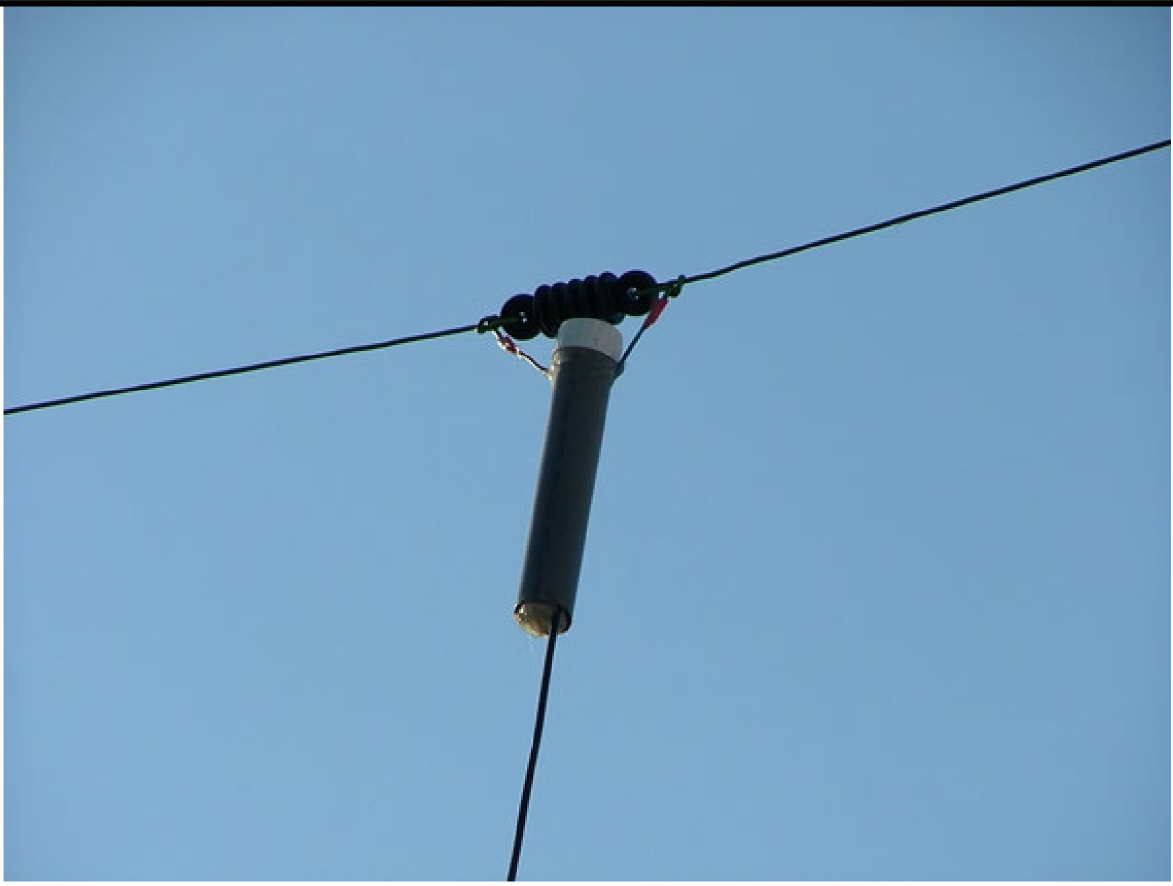
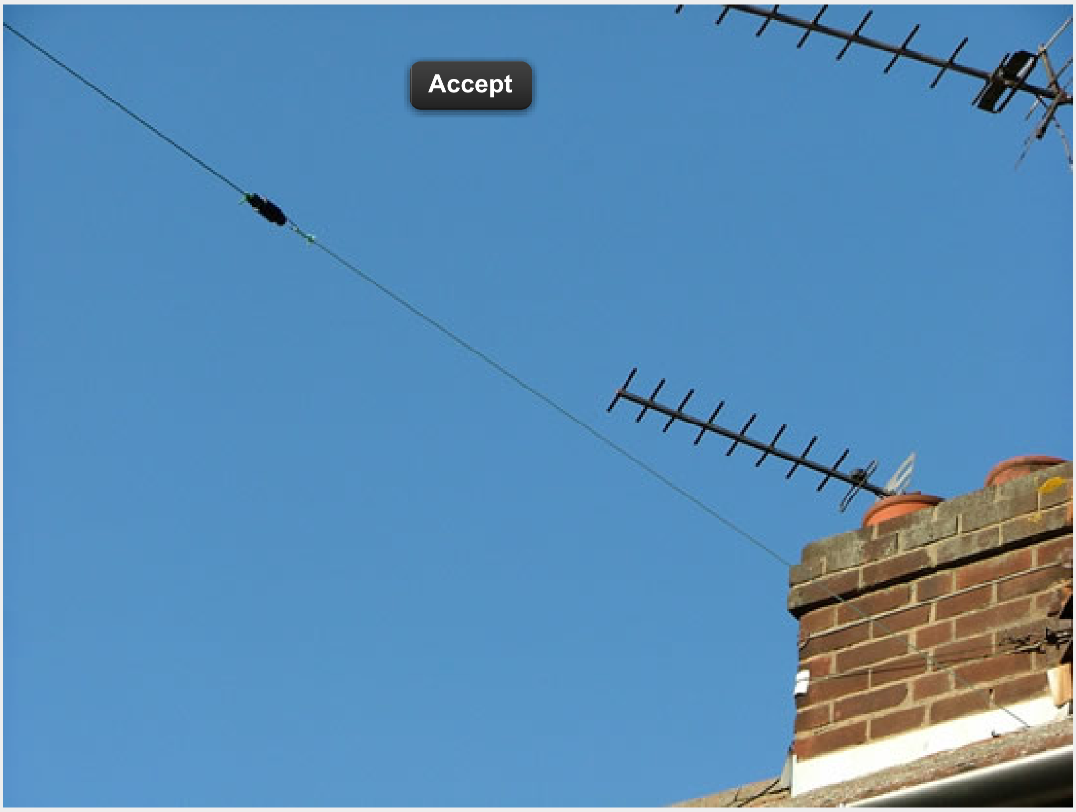
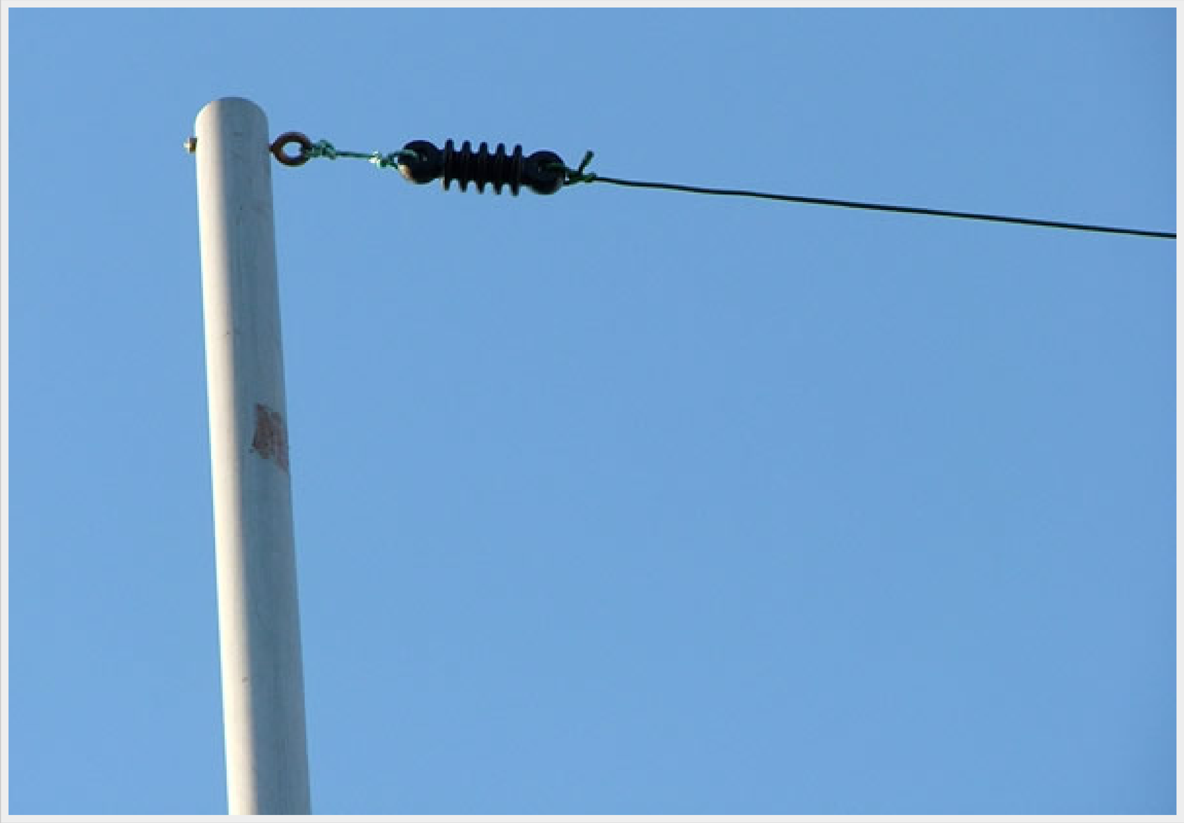
4:1 Balun 1-30MHz - MØUKD







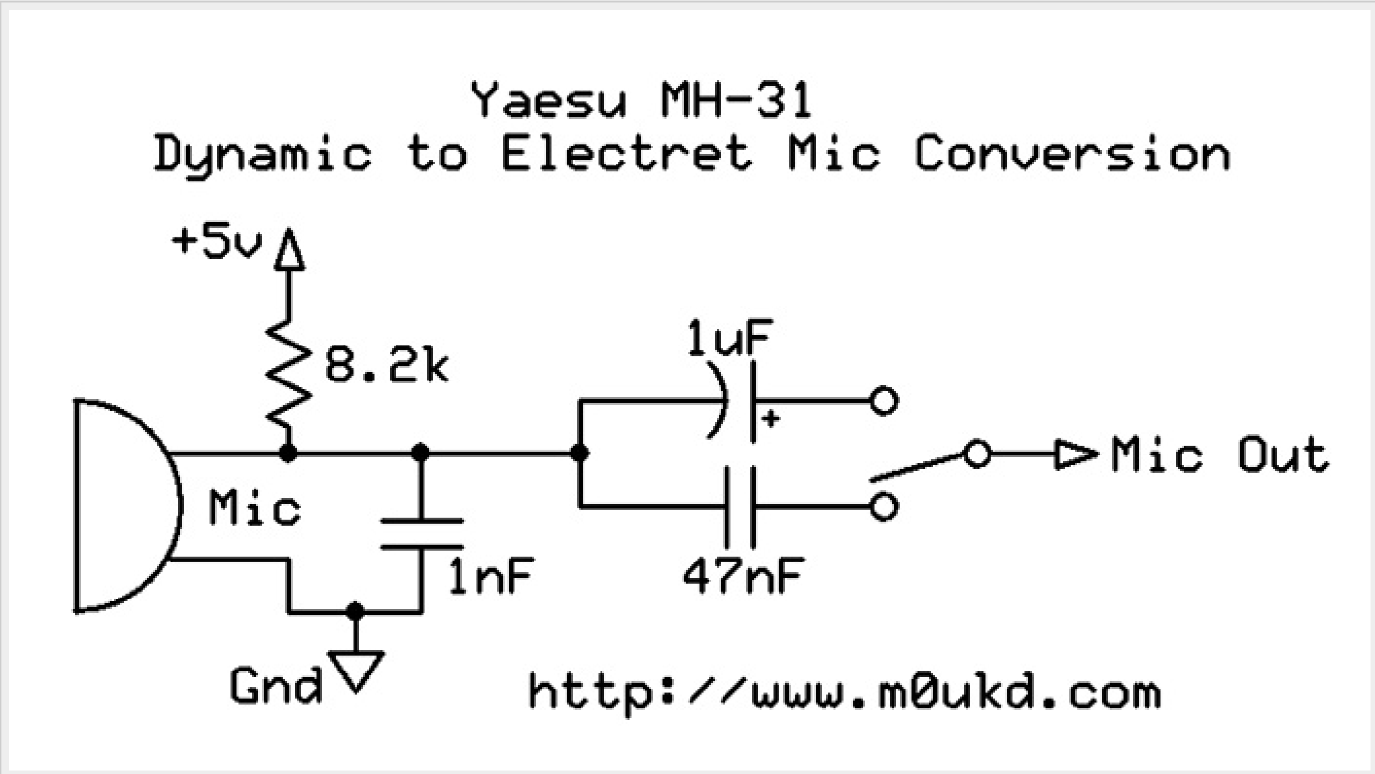




Yaesu MH-31 Electret Condenser Mic Modification

When they built the FT-817, I think its such a shame they did not include a speech compressor. A good speech compressor makes such a huge difference to talk power and average RF power and is very helpful when using only 5w SSB. I did try a 'One Big Punch' speech compressor board that fits inside the MH-31 but I wasnt impressed with its performance, especially the noise gate. I found that with the MH-31 microphone, I have to have the mic gain set to 100 when using SSB and even then talk quite strongly within a few inches of the microphone. Even then I dont think the standard dynamic mic element sounds that good.

One great thing with the MH-31 is that there is an unused 5v supply connection. This allows an electret condenser microphone element to be used in place of the standard dynamic element. I decided to experiment with this, and after some testing I came up with the circuit below.

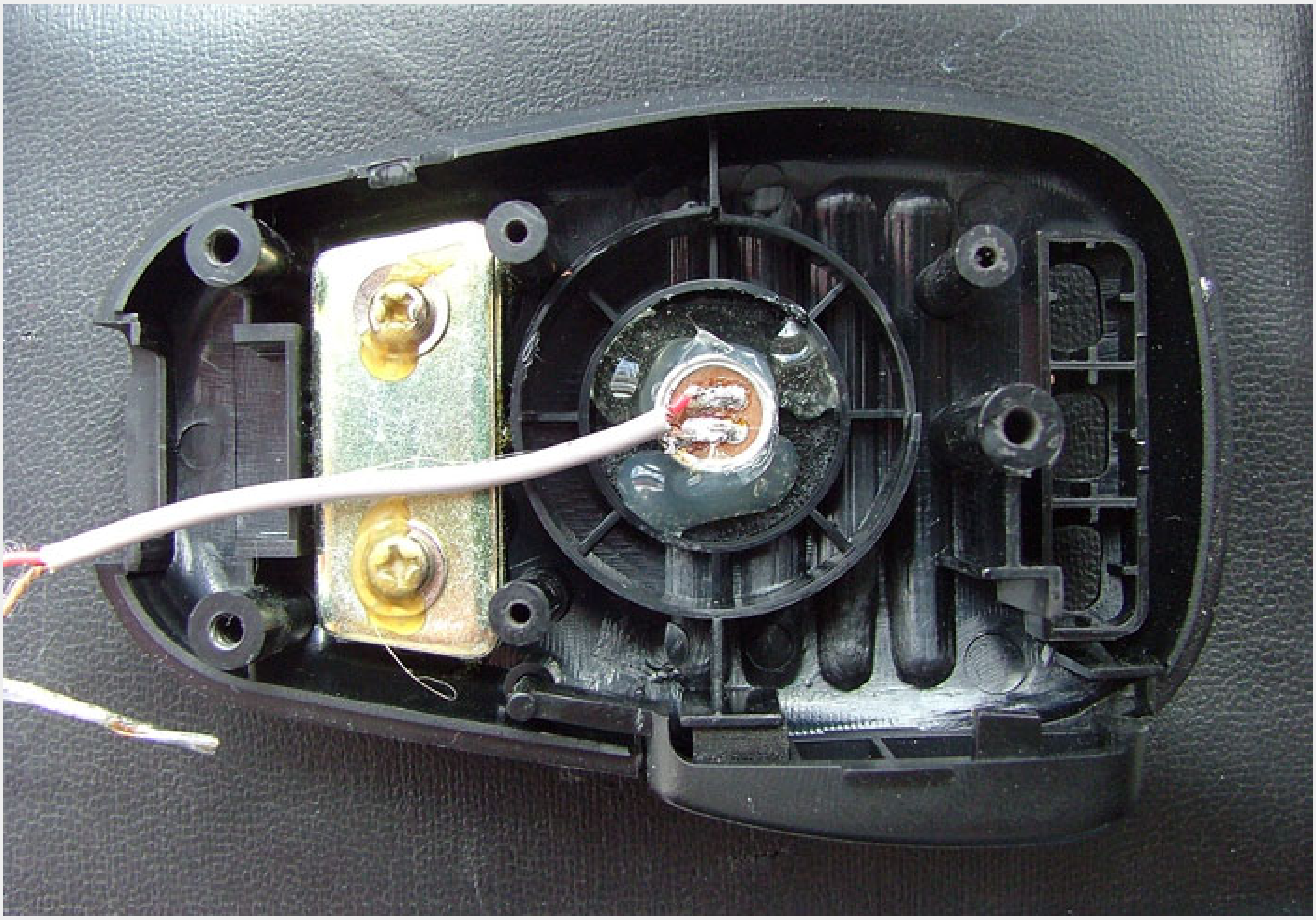


Condenser microphone schematic for the Yaesu MH-31

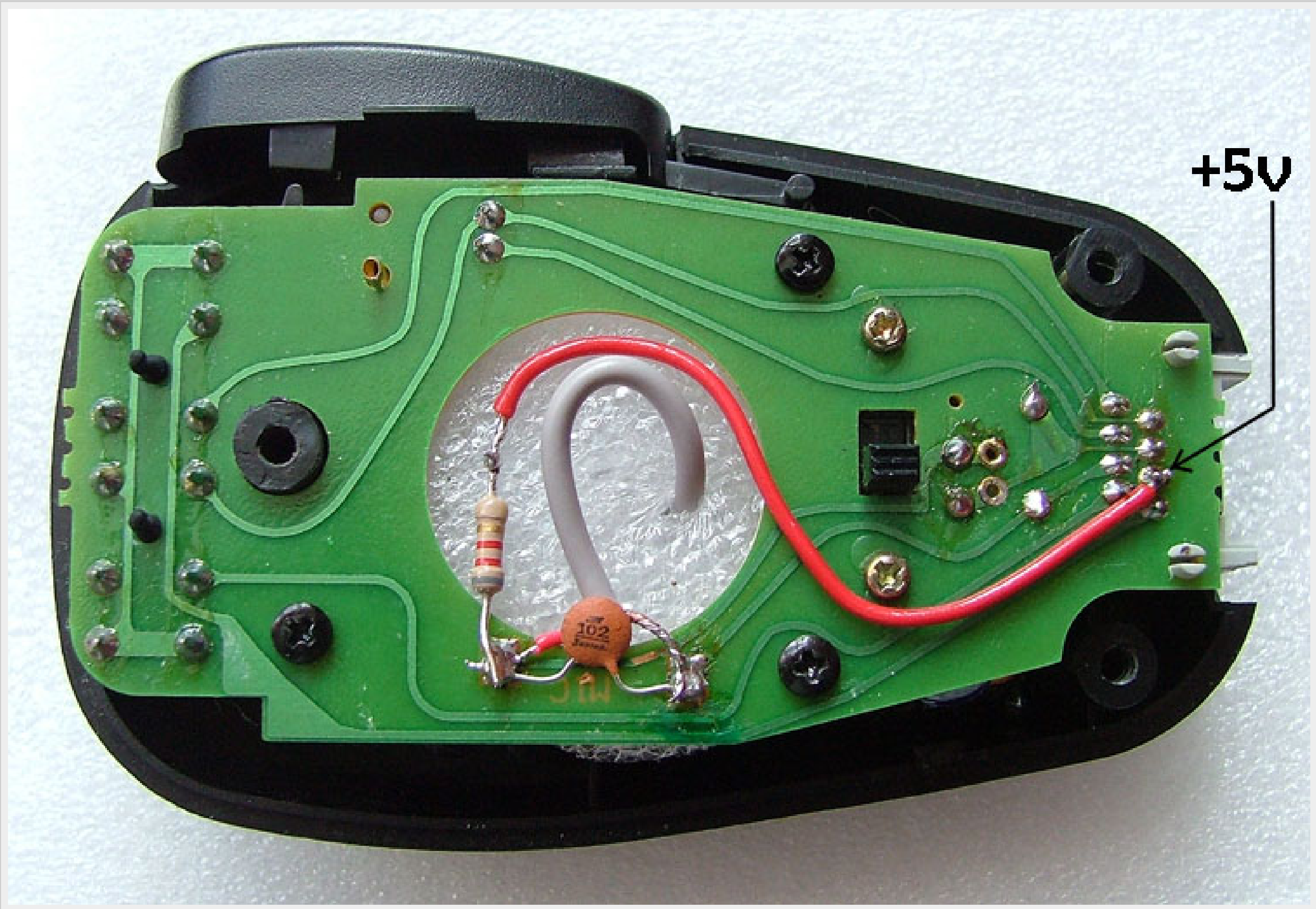
As you can see, I'm still using the tone selector switch as a high pass filter to provide some tone adjustment. I find that the 47nF setting works great for SSB by reducing the low frequency and putting more of the midrange into useful talk power. For FM I use the 1uF setting which provides more full range audio suited to FM 'Rag chewing'. This setup also provides much more mic gain options. With the stronger gain of the electret mic element, I now use between 30 and 40 mic gain on the FT-817 on SSB as well as now being able to talk further away from the mic. I find talking ~6 inches away from the mic much improves voice clarity. Something I found I just couldnt do with the standard dynamic element.

Some photo's are below. I have stuck the electret element onto the front of the mic with some hot glue, then

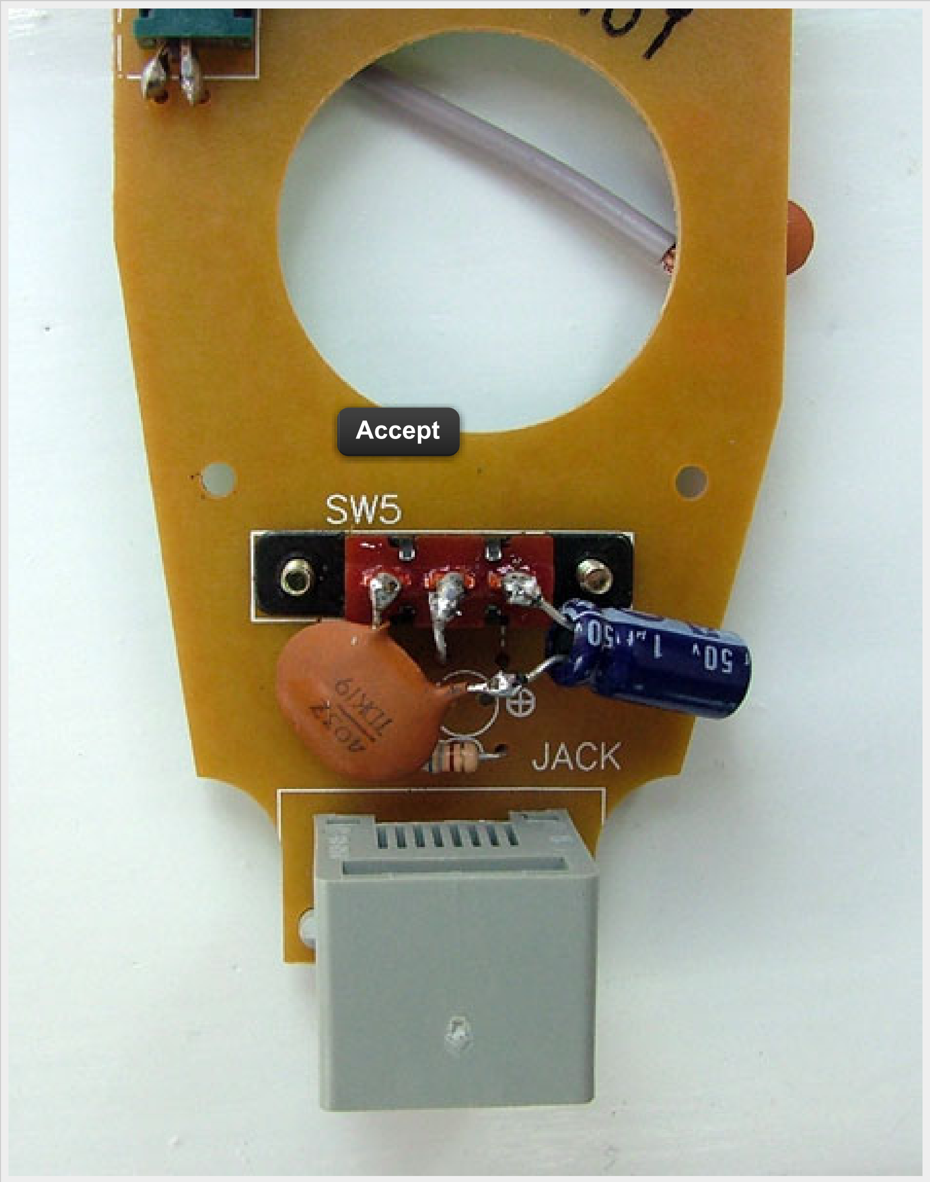
If you seem to share the same issues with the MH-31 microphone, I suggest giving this a go. Please let me know how you think it performs!



Electret element glued in place



The completed modification



Tone switching arrangement

VK5AJL HOME | PROJECT INDEX | INFORMATION

SWR METER

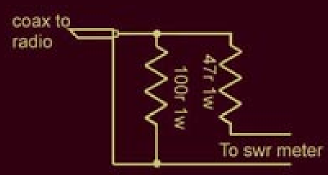
BUILD YOUR OWN STRIP LINE SWR METER

The text of this project should be read in conjunction with STANDING WAVES in the info section. You should also note, I have used the term "striplines". Technically striplines have a ground plane on both sides and those here are technically micro-striplnes because they only have one.

Here is a way to build your own accurate homebrew SWR meter and customise it to your own needs. It costs only a few dollars to add extra frequencies and other functions such as RF Volts. You can make your own pickups for HF, VHF, UHF and higher. With a bit of messing around and matching with a few resistor values, it can also be used to measure power levels or RF voltage.

BEFORE STARTING

To be making a SWR meter, I needed something to test it as I went. The obvious choice is a radio but I needed to be able to test infinite SWRs both open and short circuit. Either might blow up a radio so I built the following short attenuation testing circuit.



With this circuit I could get the meter going for UHF using an old 5w CB radio I don't use anymore and on 2m I could use a 5w handheld. Since it is forward and reflected power, at the strip lines, we are looking for, any attenuated signal will do. I used some two watt carbon film resistors I had knocking around. They have to absorb 5 watts but only for a second. I did cook a few and warmed a few up but they are cheaper than a radio. (Do not use high power WIRE WOUND resistors.) Beware also of some high power carbon film resistors. They can also be "wound", introducing more inductance. Note, there will be inductance anyway by virtue of their length. If in doubt, buy a couple of extra and scrape the paint off one. A couple of 47 ohm 1w resistors in series can be used instead of the 100 ohm or a couple of 220R in parallel. It really doesn't matter.

Just like "db", "SWR" is a comparrison value. It says nothing about how much power is travelling in either direction. The value will be the same at 100mW or 1kW.

In the worst case scenarios, a short circuit means the radio is still working into at least 32 ohms and a maximum of 100 ohms with a complete open circuit. In these cases the forward and reflected voltage and/or power should be the same.

THE ONLY WAY TO MEASURE SWR IS WITH (MICRO)STRIP LINES - SEE WHY A BRIDGE DOESN'T MEASURE SWR. A bridge is two sets of series components with a BRIDGE across the central connections. Micro-stripline SWR pickups are NOT bridges.

HOW TO DO IT

The first thing to do is decide what frequencies we want to use the meter for. It is pretty useless to measure several Gigalitres of water with a medicine glass just as a few millilitres are impossible to measure with a flow

meter suitable for Gigalitres. You wouldn't even get it wet. The meter described here works from about 28MHz through to 430MHz with 5 or 10 watts required at 28MHz and only a watt or so at 430. For a better HF meter, all you have to do is make it longer OR use an op-amp to amplify the signals. Given the length of the strips, this metre should work up to 1.4GHz (200mm wave length/4=50mm long) but I wouldn't use it at over 430MHz (except perhaps UHF CB). At 144MHz it needs about 2 watts or so. You need to watch the meter itself though. The strip lines themselves are suitable for hundreds of watts but the meter will burn out with too much power.

Materials:-

1) A BNC chasis socket and chasis plug or similar.
2) A couple of BAT out of hell diodes like BAT 81, BAT 42 or BAT something else.
3) A small piece of double sided PCB, 1.6mm thick and 50mm x 30mm.
4) A couple of small caps from about 220 pf to 1n, it doesn't really matter.
5) A single or double ganged pot (anywhere from 1k to 10k) linear or log.
6) A DPDT switch. Better, a 4 or 6 position double pole switch.
7) Some twin shielded audio cable.
8) Both a 3.5mm stereo jack and chasis socket.
9) Some PCB etch like Ferric chloride or Ammonium persulhate. I have even done it with Nitric Acid. You can also simply scrape the copper away with a hacksaw blade.
10) A 100uA panel meter or similar.
11) Possibly a multi-position switch and a few attenuating resistors.

BOARD DIMENSIONS

All of the boards I make are 30mm wide but this is not really any sort os strict rule. For 6m to 70cm, 50mm long works well although more power is needed at 50MHz than 430MHz. I also use one 30mm x 30mm for the 70cm end and a board 150mm which works wuite well down to 40m.

CONSTRUCTION

On one side of the PCB, etch, cut or grind the pattern below. Simple instructions can be found on the making PCBs page. The black areas are the copper while the white areas are etched away. Only a few values are critical but both sides should be the same. The central transmission line needs to be 6mm wide (on 1.6mm PCB) so that a 50 ohm transmission line characteristic is maintained through the meter. This is not all that important because the lines should be well less than ¼R.

The gap between the central micro-stripline and pickup strips needs to be as close as you can manage and also, more critically, as close to the same as you can manage. The smaller the gap, the harder it is to get them the same but I try for 2 mm. I made three before I was satisfied that I had them close enough. With a gap of only .5mm, the pickup side will handle kilowatts at 50Ω.

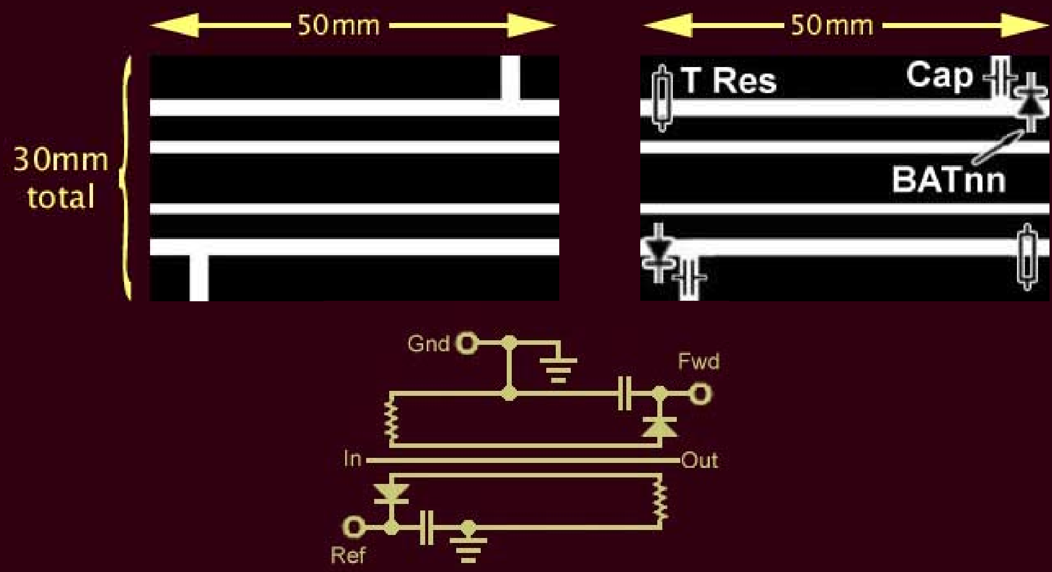
The distance between the strip lines to the ground on either side needs to be about the same on both sides but is not so critical. Even though the permittivity of fibreglass is around 4 or 5, the capacitance to ground through the board will still be much greater than to the sides.

Not only is the central conductor part of a 50 ohm transmission line, the pickup strip lines are also transmission lines and need to be correctly terminated at one end. The characteristic impedance for a micro-stripline is:-

$$Z_0 = \sqrt{L/C} = 377 \times (t/w) \times Er^{-0.5}$$

where t/w is the ratio of thickness of the material to width of the strip (so inch, mm or cubits doesn't matter) and Er is the relative dieletric constant of the material which for firbe glass PCB circuit board is about 4.5.

Once done, populate the board as shown below. If you are confident enough with SMD, the tracks shoud be close enough to use them. This makes a very neat little unit.

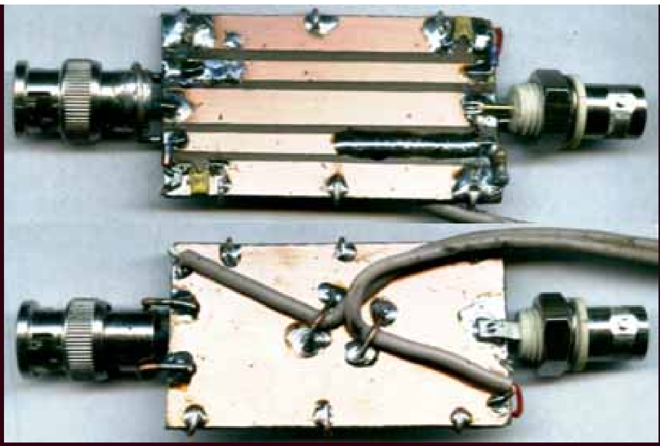


The ground on both sides of the PCB also need to be suitably connected. If you have some copper foil, it is best to wrap some along the entire length of both sides. I didn't have any at the time so used 3 fairly thick pieces of bare copper wire as shown in the diagram below.

The terminating resistors are critical but only in so far as they should be the same and somewhere near the correct terminating value for the width of the pickup strips. Correct SWR readings can be obtained with just about any resistor from 10r to 1k0 but more power may be needed. The diodes should be of the BAT variety, almost any number will do but the faster the better. BAT 81s are best. The bypass caps can be almost anything from 50p to 1uF but need to be plate type and NOT wound such as polyester ie. non-inductive. I tried putting a 220p on one side and a 10n on the other and the meter read the same as it did when I swapped them.

Some meters recommend germanium diodes because they have a lower forward voltage drop. This is true and there is a voltage drop across the diode in this meter but I tried germanium and they just didn't make it in speed. In any case, the forward voltage drop becomes lower as the current decreases. At full scale deflection on this meter the forward drop across a BAT 81 is about .15 volts and less at the lowest readings. At a swr value of 1.01:1 the metre will read 1:1. This is more than good enough to test an antenna. The BAT 81s are so fast the readings using them were higher than with any germanium diode I tried. This means the voltage drop across the diode was far less with a BAT 81 or even 42 than it was with germanium (unless there is some germanium I didn't try). Anyway, take your own pick and try a few yourself.

The lead is made from twin shielded audio cable and soldered on to the diode/capacitor junction as shown here. The outer shield of the twin audio cable can be connected to ground on the inder side of the board. I also used a couple of component leads (from the resistors) to hold the cable firmly.



HOW IT WORKS

The easiest way to explain the workings is to consider that what we want is the Standing Wave Ratio from the output of the meter to the end of the antenna. Once the meter is removed and the end of the cable plugged into the radio, this is what the radio will see. If we place the meter at the node, shown below, the transceiver to the left and the reflection point to the right, everything to the right of the meter represents the antenna and to the left, the wave source (radio). The antenna includes any coax or feedline.

Note, this is not quite the actual situation. There will be no such voltage pattern in the main conductor. It is only in the two pickup strips where it will be noticed.

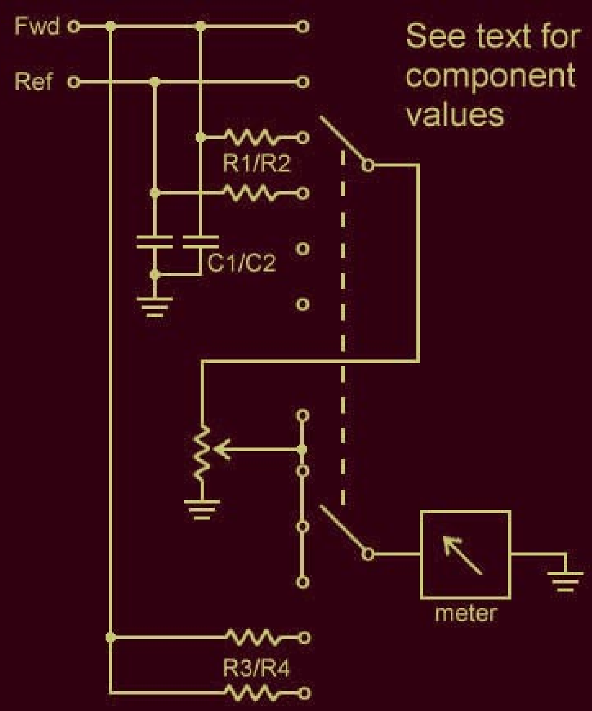
When the antenna and the coax or any other transmission line between the meter and the end of the antenna is in tune, there will be 0 volts at the right end of the top pickup strip because it is right on the node. The left end will also have 0 volts because it is connected to the coax ground (or equivalent there) via the terminating resistor and no current will flow in the top strip. On the other hand the lower strip will have 0 volts on the right hand end (coax outer) but will have some volts on the left hand end so volts picked up here will cause a current flow through the meter. This isn't quite the way it works but will do here. In actual fact, the correctly terminated end (with the resistor) will develop only minimal volts but the unterminated end will produce a signal according to the distance from the node.

THE METER PART

I wanted to use the same meter for a number of purposes. Not only do I have a SWR pickup but also a bridge for measuring impedance, a pickup for signal testing and both a shorter and longer pickup for UHF and HF respectively.

I used a simple analog panel meter but there is no reason why the pickups described above couldn't be connected to something else. I had a 100uA panel meter in one of my draws and used that but almost any meter is suitable. The only thing to remember is that the higher the current required for full scale deflection the more power is needed to drive it. This was mounted into a box made from PCB material, together with a

potentiometer and a 2 pole 6 position PLASTIC or ceramic style switch. Do NOT use bakelite. The side of this box has a 3.5mm stereo socket to accept the audio cable from the various sensors.



The wiring inside the box is shown at left. The two direct inputs are used for low power while those with resistors R1/R2 allow for higher powers. R1 and R2 need to be matched. This can be done by measuring several from the same batch. Their values will depend on your choice of meter. You may have to play around with the values.

Capacitors C1 and C2 bypass any RF to ground and can be almost any value around 1nF and preferably ceramic. The potentiometer value will also depend on your choice of meter but one with a value ten times the coil resistance of the meter works well.

Resistors R3/R4 are used with an RF probe (details later) which also plug into the 3.5 socket but using a mono plug. R3 and R4 are different values calculated and adjusted for RF volts (10 and 100). Their values will also depend on your choice of meter.

Once the values were determined and mounted onto the switch contacts, a new front to the meter similar to the one shown here can be made with a paint program, printed and stuck to the front of the meter. The front cover usually comes off with ease. Details of meter deflection and SWR are given below. (The one shown is for a simple meter with a SPDT switch for SWR only).

ALTERNATIVELY:- Click image for full sized graphic. You can stretch it, scew it, enlarge it, combine it with whatever else you want to add or generally play with it using a graphics program then print it out for you own meter.

ADJUSTMENT

If you have done a very good job with the gap between the central strip line and the side pickup strips, the meter should read reasonably into a 50 ohm dummy load. That is, one way should read full scale and the other zero. It should also read well into quite high and low resistive dummy loads. A 10 ohm resisitive load should still read nearly 1:1 SWR as should a few hundred ohms RESISTIVE because we are trying to measure STANDING WAVE RATIO NOT IMPEDANCE. Of course, by the time you get to short or open circuits, both forward and reflected should be the same and half way up the meter, or thereabouts.

Calibration is simple. Work the meter using a few watts into an open circuit from the signal attenuator at the top of the page so you don't blow up the radio. Both FORWARD and REFLECTED, need to be the same so if one picks up better, it will have a higher reading. The best way to adjust the meter is to help the low reading strip along **OR** scrape away some copper from the better one. I adjusted mine by adding a bit of solder and helping the low reading strip along by making it thicker. ALLOW THE SOLDER TO COOL PROPERLY BEFORE CHECKING BECAUSE THE TEMPERATURE ALSO CHANGES THE READING.

FINAL CHECK

Once you have the meter reading correctly into an open circuit and dummy loads, turn the meter around ie. replace the input for the output and vice versa. It should read the same except FORWARD and REVERSE are the other way around. Lastly, make a simple 1/4 wave antenna out of a piece of wire and try it. If you make it obviously too long then snip bits off the meter should reflect the changes.

SWR VALUES FOR METER DEFLECTION

First figure of pair is SWR. Second is percentage of meter deflection.
1.0 0.0 | 1.1 4.8 | 1.2 9.1 | 1.3 13.0 | 1.4 16.7 | 1.5 20.0 | 1.6 23.1 | 1.7 25.9 | 1.8 28.6 | 1.9 31.0 | 2.0 33.3 | 2.2 37.5 |
2.4 41.2 | 2.6 44.4 | 2.8 47.4 | 3.0 50.0 | 3.5 55.6 | 4.0 60.0 | 4.5 63.6 | 5.0 66.7 | 6.0 71.4 | 7.0 75.0 | 8.0 77.8 |
9.0 80.0 | 10 81.8 | 12 84.6 | 14 86.7 | 16 88.2 | 18 89.5 | 20 90.5 | 25 92.3 | 30 93.5

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160 Meter Dipole Antenna at W5JGV

At the new QTH in Natchitoches, Louisiana

by W5JGV

Match 19, 2007

It's been a few months since Bonnie (KB5YSE) and I moved to our new home in Natchitoches, Louisiana. We relocated here about a year after hurricane Katrina substantially rearranged our lives. We managed to retire (again) and plan to spend a lot of tine doing all the things we have always wanted to do, but never quire seemed to find the time to do. You know how that is!

One of the things we have planned to do is to erect another building close to the house. the new building will become part art studio for Bonnie, part storage for all the extra "Junque" we have accumulated and can't bear to throw away {1}, and part Ham Shack for our radio gear and my experiments. There's already a shop where I can do my mechanical and woodworking stuff. But, we haven't got around to constructing the new building yet, so the hamshack, such as it is, is presently confined to a very small corner of the laundry room, along with the rack full of computer networking hardware and Internet satellite equipment.

Well, I quickly realized that I needed some sort of an antenna if I was to work anybody on the HF bands. As a first try, I ran some 17 gauge aluminum electric fence wire from the side of the house closest to the "hamshack" out to a handy tree about 20 meters or so away from the house. I used a length of twine to hold the wire to the tree, and a couple of electric fence insulators at the house. Using a spare 1:4 balun connected between the antenna wire and the house water pipes, I connected the balun input to some old cable TV coax and ran it inside the house under the door and on to the antenna tuner. The rig, of course, is one of my two Yaesu FT-747GX's.

Well, it worked - sort of. I could hear stuff on just about every band, and even make contacts! But - I also "contacted" all the TV's in the house (no cable here; the closest major market TV station is about 55 miles away), the house alarm system, and every computer speaker in the house, as well as several of the Ground Fault Circuit Interrupters. Not good. I figured I had better get the antenna away from the house. Now.

After a leisurely walk around the estate with tape measure in hand, I managed to locate several nicely spaced trees that looked as though they would serve to hold up a 160 meter dipole. Did I mention that we have trees here? Lots and lots of trees. In fact, about 12 acres of them. It's hard to site an antenna for the forest full of trees. I had to run the antenna between the trunks of the trees. That (and the fact that I could not figure out hot to get really high in the trees) limited me to installing the antenna at about the height of my extension ladder and below the major tree branches, which turned out to be about 20 feet above the ground.

The antenna is oriented on a North-South axis, more or less. It dog-legs a bit around several trees, but that does not seem to interfere with its operation at all. It is fed with home-made open wire feedline. Let's take a look at some of the pictures...

This is the North end of the antenna. A big screw is placed in the tree, and a 16 cm length of gray PVC pipe was used as an insulator. The antenna wire is some of my handy 17 Gauge aluminum electric fence wire. It's strong enough to hold up pretty well to the wind, and becomes almost invisible after a few weeks in the weather.

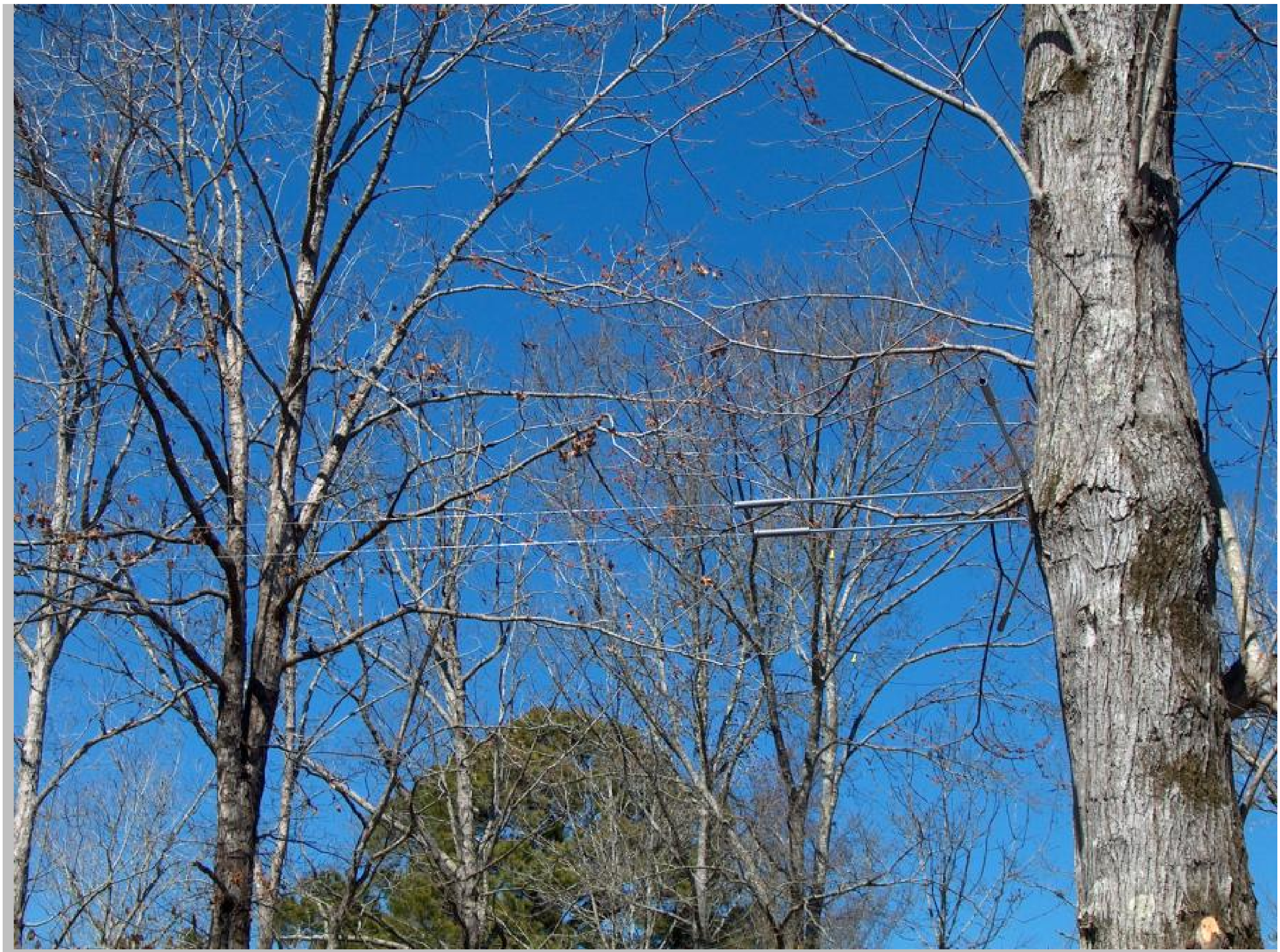
The South end of the antenna is attached to its supporting tree in the same manner as the North end. If you look closely, you can see the screw in the tree trunk.

Where the antenna wire passes close by several trees, it is held away from the tree trunk by the use of a nail-on electric fence insulator. The antenna wire is not fastened firmly to the insulator, but is allowed to slide freely through it.

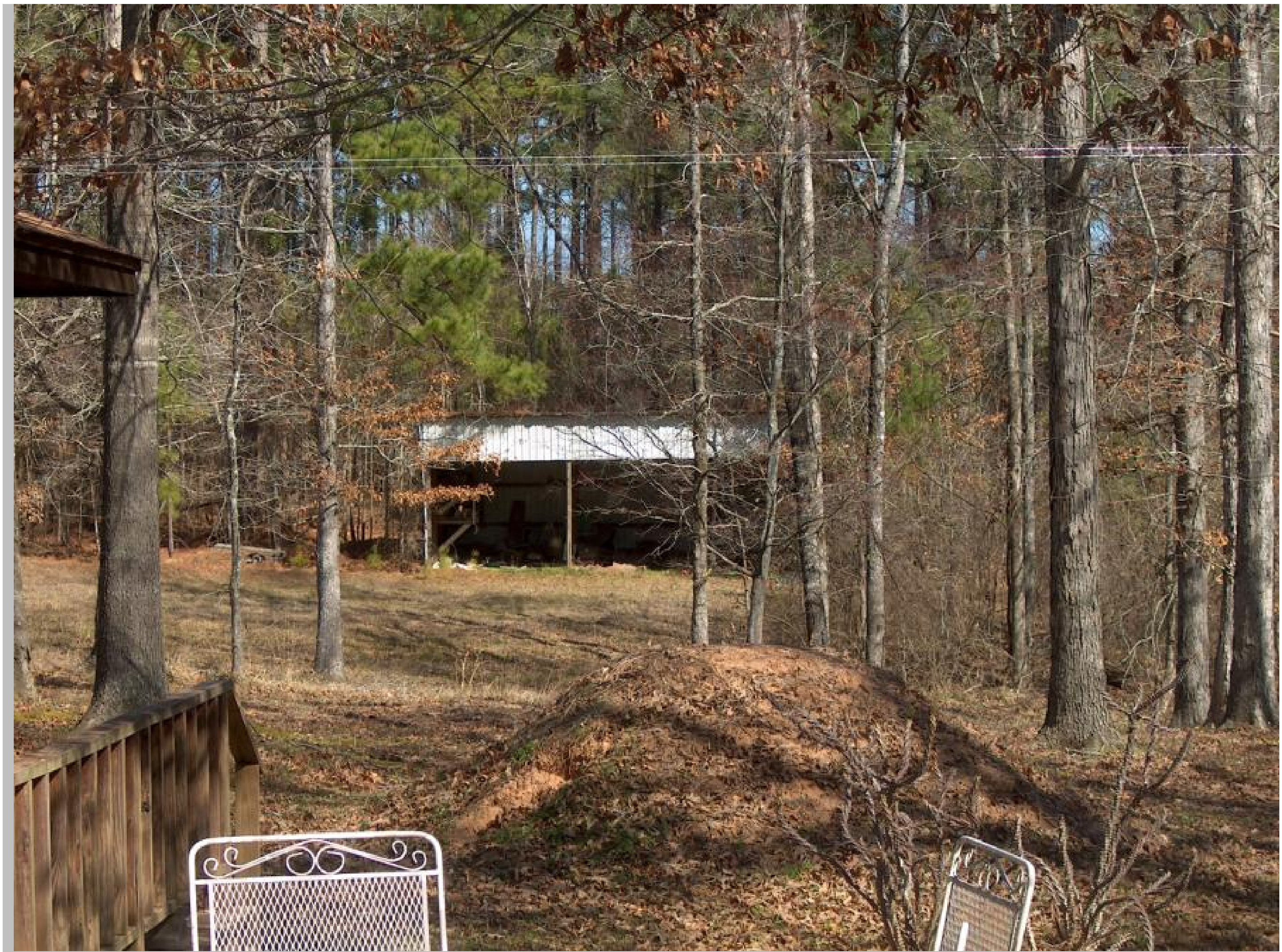
The center of the antenna is where the real action takes place. I screwed a length of thin wall electrical metallic tubing (EMT) to the tree trunk and attached four heavy "screen door" springs to the EMT. The springs running to the left and right in the picture apply tension to the insulators that are attached to the North and South legs of the dipole antenna. The springs running towards the top of the picture apply tension to the insulators that are connected to the open wire feedline running back to the house and hamshack. If you look carefully, you can see two yellow "wire nuts" apparently suspended in the air between the dipole arm and feedline springs. They are where the feedline connects to the dipole arms.

A close-up view of the EMT as it is attached to the tree.

The springs are attached to the PVC pipe insulators using a "dry-wall" screw driven through the pipe. That saves drilling a hole! (Did I tell you I'm lazy?)



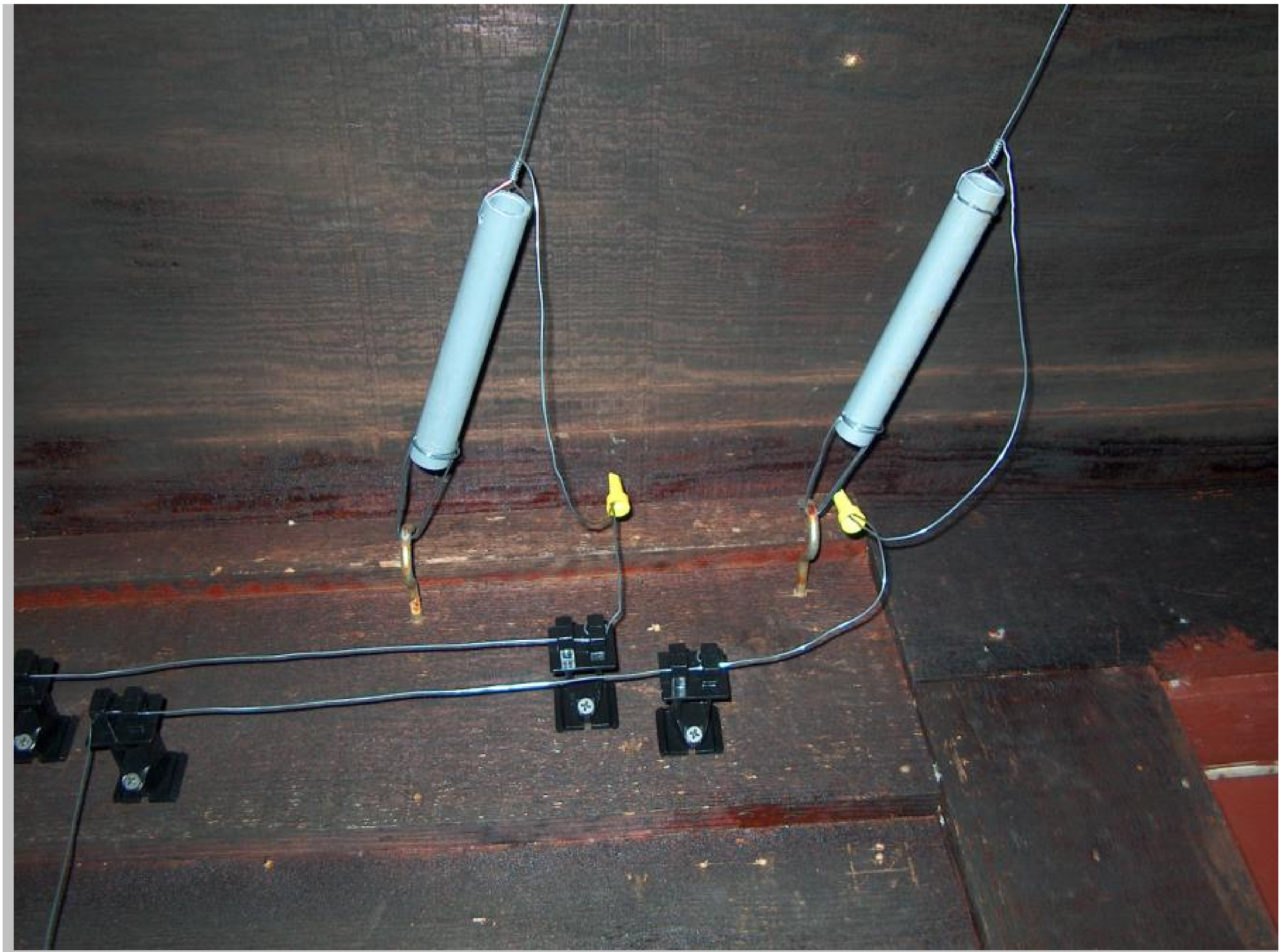
This is a side view of the center of the dipole and the feedline, which is visible from left to right in the picture. The feedline is made from the same 17 gauge aluminum electric fence wire as is the antenna. (I have lots of it on hand!) I didn't bother to calculate the impedance of the line, since the loss is so low anyway. The wire-to-wire spacing is about 23 cm in case you're curious and want to calculate the Zo of the line. No insulators were used, since the spring tensions the feedlines very well and they don't move relative to each other when the wind blows.



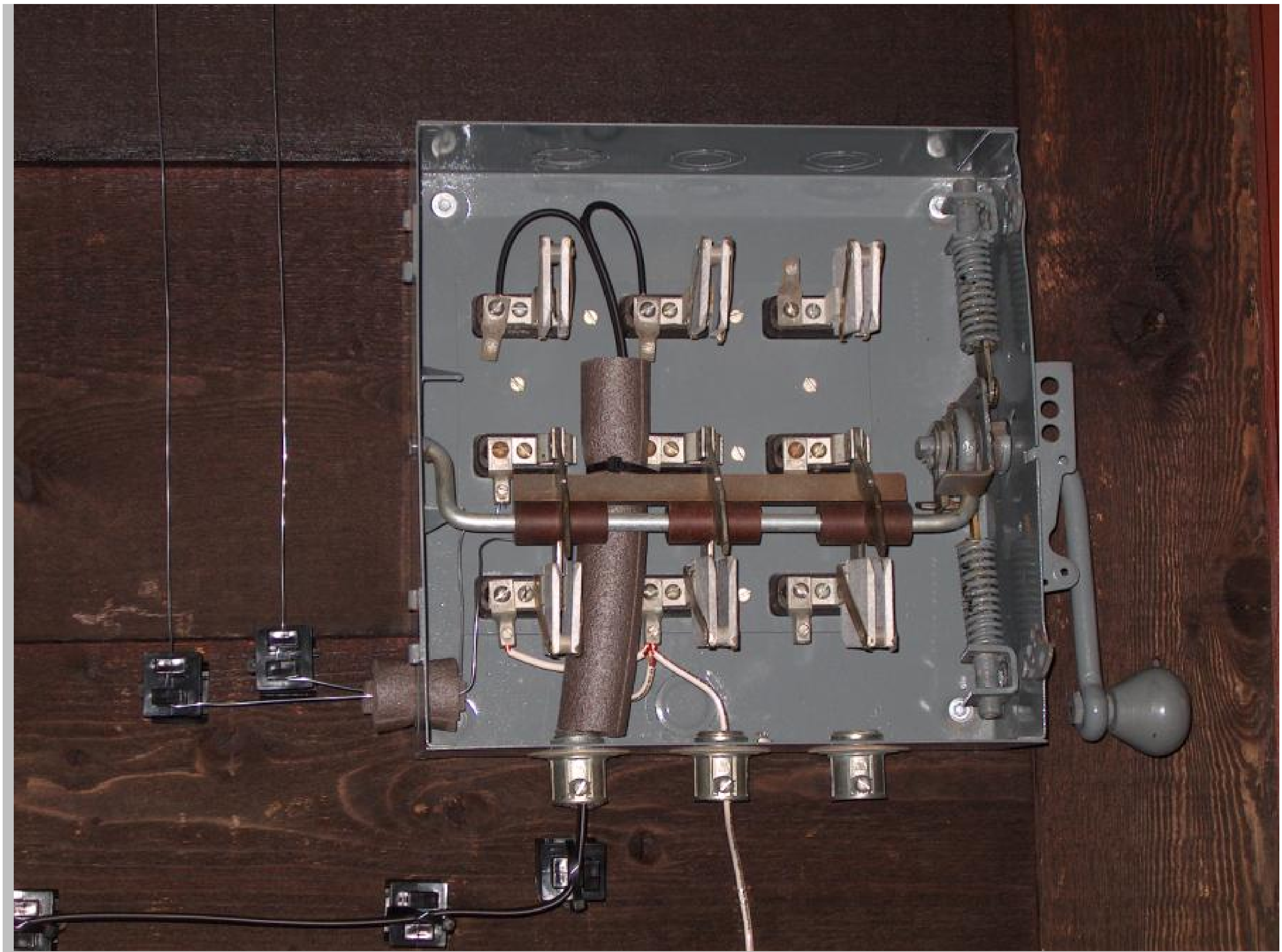
The feedline is just visible running across the picture. The shack is to the left, and the antenna is to the right. The feedline is about 31 meters long. The mound of earth in the foreground is not a fire ant hill (although some do get almost that large) but is leftover dirt brought in to fill some tree stump holes after trees uprooted by hurricane Rita (Sept 2005) were removed.

At the hamshack, the feedlines terminate at insulators mounted under the eves of the house. They are led into a 60 Ampere DPDT switchbox so that the feedlines can be disconnected from the shack and grounded during storms. There's a ground rod set into the earth directly beneath the switchbox. This is also connected directly to the solid copper cold water pipes in the house.

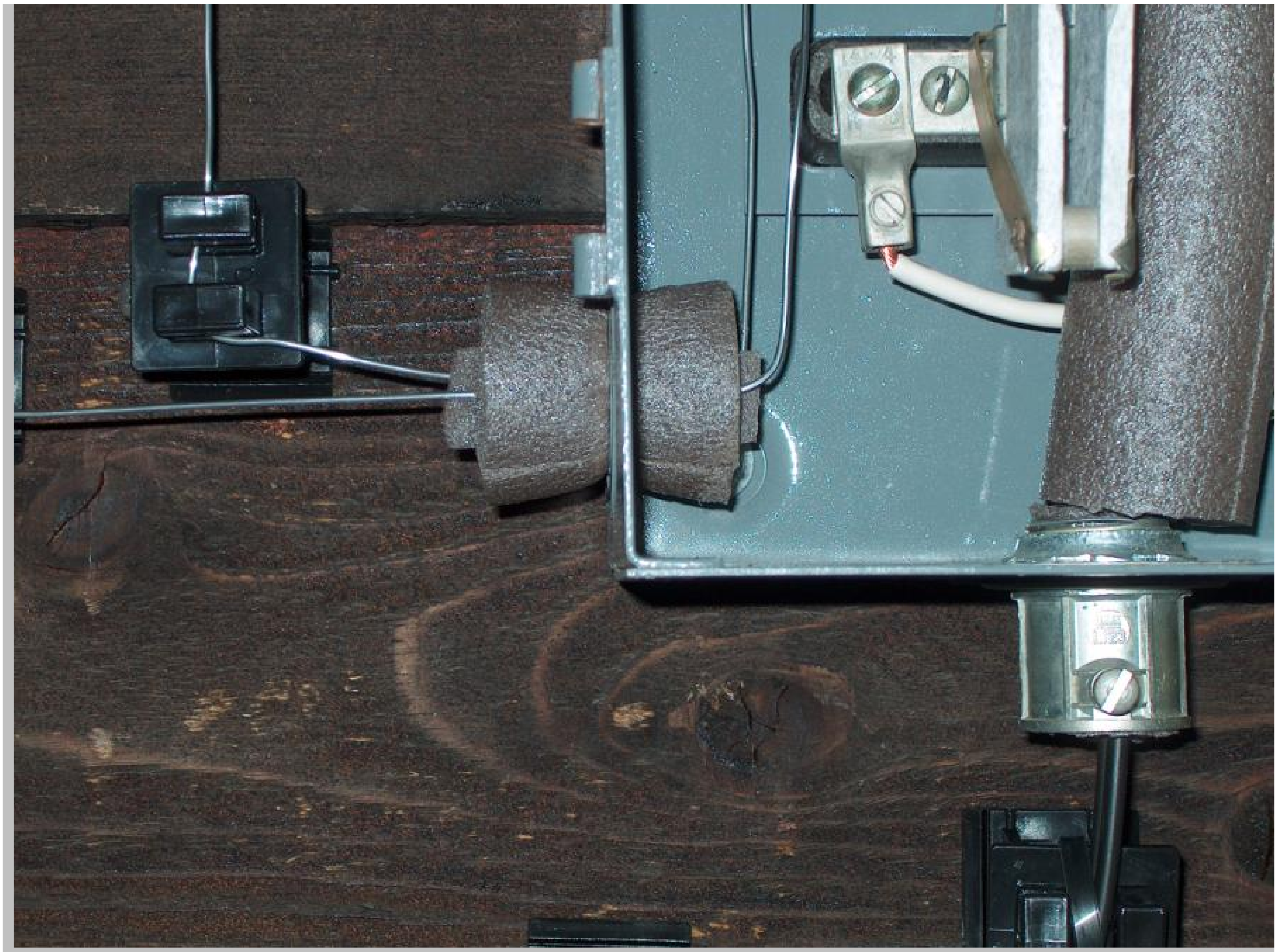
The feedlines are held away from the eves by using two nail-in electric fence insulators. More of these insulators are used to support the feedlines as they go down to the switch box.



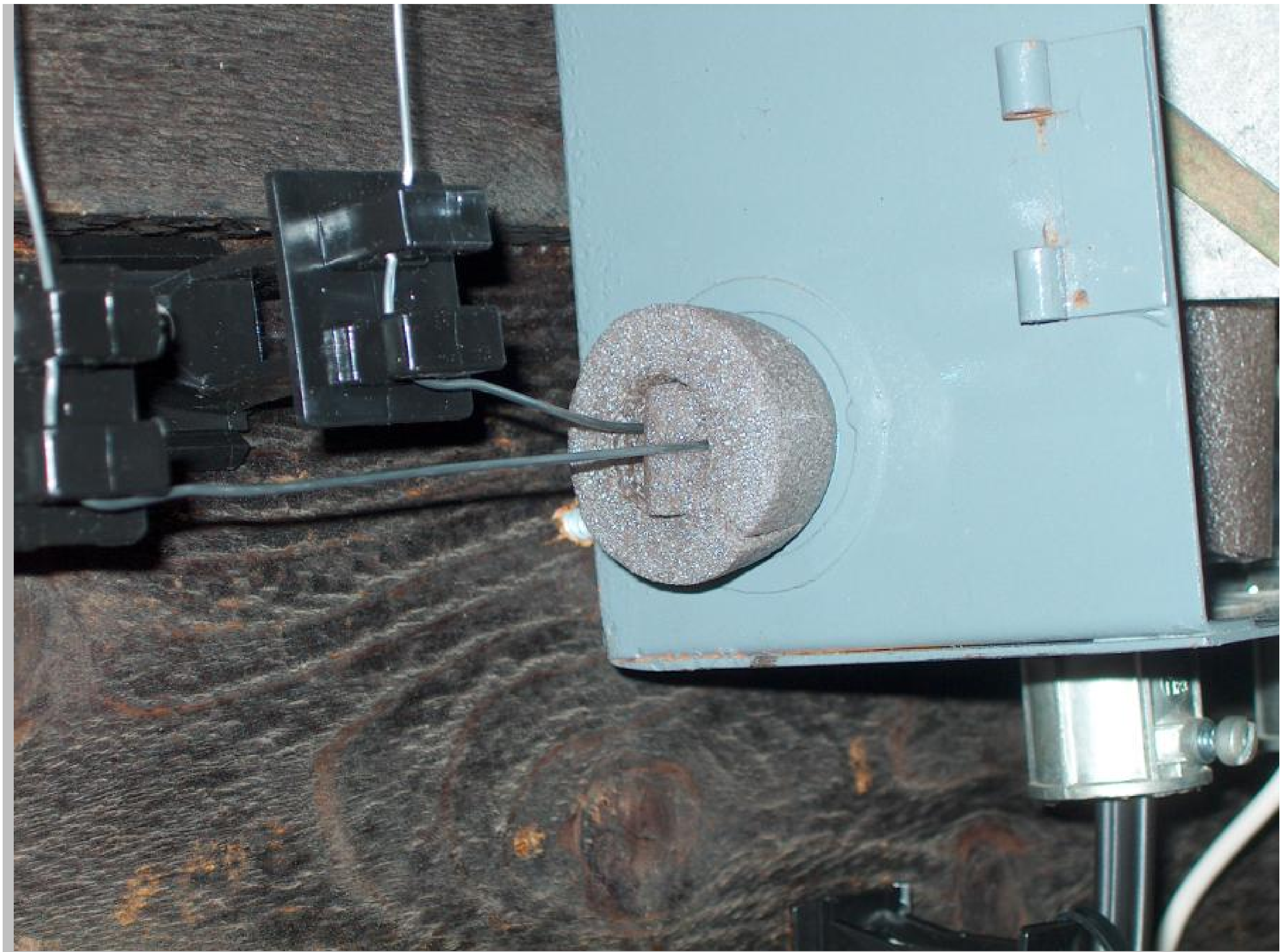
A better view of the shack end of the feedlines.



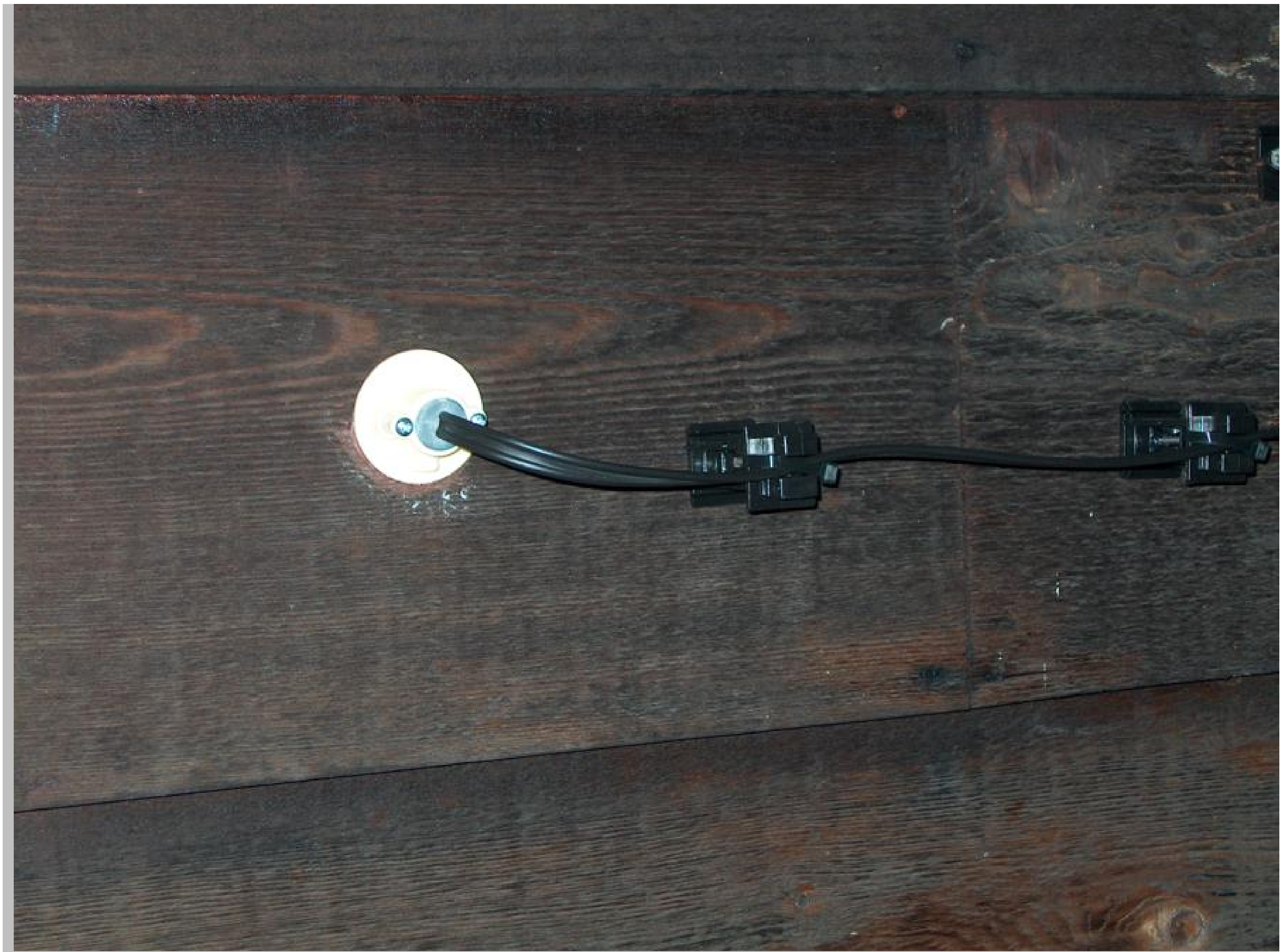
Inside the switch box. Although this switch was designed for 60 Hz use, when the RF power level is limited to 100 watts, there is no noticeable heating of any of the insulators in the switch. You can see the open wire feedlines entering at the bottom left of the box. The white wire exiting the box at the lower center goes to the ground rod. The switch is shown in the feedline grounded position. Entering the box at the lower left is the 300-Ohm twin-lead that connects the switch to the antenna tuner inside the hamshack. It is centered in the silver-colored fitting where it enters the box by using some closed-cell polyurethane foam of the type used to insulate water pipes. Another length of this foam is used to space the twin-lead away from any metal objects inside the box.



This view shows how the foam is used to insulate the feedlines from the metal case of the box. It also keeps rain water and insects out of the box interior.



This oblique view shows how I cut a section of the foam and stuffed it in between the feed wires to prevent them from short circuiting.



Finally, the 300-Ohm feedline goes through the wall of the house to the antenna tuner. I used one of those polystyrene plastic tube assemblies that were commonly used for just this purpose years ago when outdoor TV antennas were more common. I hadn't seen one in years, but guess what - the local Radio Shack store in this area still sells them! Since they are cheap, I bought a bunch of them. They are useful for getting wires and cables through walls and for cutting into short lengths to make low-loss coils.

I mentioned before that the antenna is almost invisible - see of you can find the antenna in these pictures!

The feedline is running to the left.

The South end of the antenna is to the right center of the picture.

This is the middle of the South leg of the dipole.

The only time the entire antenna is truly visible is when the sun is just over the horizon and the antenna is wet with very fine dew drops. I expect that after the trees grow their leaves, it will be very hard to see the antenna at all. I just hope the leaves don't absorb all the signal

---

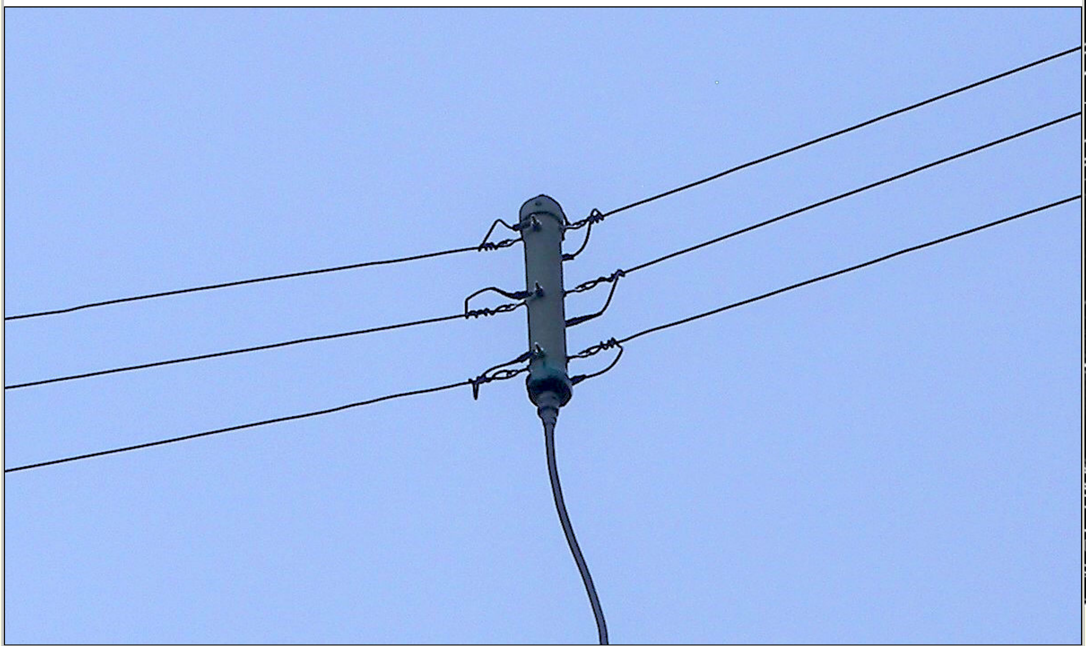
Notes: {1} Stuff - The Junk you Keep. Junk - The Stuff you throw away.

73, Ralph W5JGV

[Home]

The KL3JM MODIFIED "SRI" MULTIBAND FAN DIPOLE FOR 80 - 40 - 20 Meters

I built my SRI dipole for three bands, 80, 40 and 20 and designed it to be as light as possible since there would be no center support, just hanging between two trees.



It was based on an article on Hamuniverse.com that can be seen here. In case you don't know what an "SRI" dipole is, read the article above in the link. The antenna in this project is a modification of the techniques used to design a multiband fan type dipole with little or no tuning involved.

Since I only had 105 feet between my trees I had to use a loaded wire for the 80 meter band at 90 feet long.

K7MEM has a good web site at www.k7mem.com that I used to get the specs for this short 80 meter section loading coil.
It was made with a 51uh coil set between a 9 foot and 36 foot wire for a total of 45 feet on each side. This 90 foot length set the design for the rest of the assembly.

The center connector/insulator was made from a 14 inch length of 1 1/4 inch PVC. See photo (1) below.

The 1 1/4 inch PVC is not big enough to get your hand in but much lighter than 3 or 4 inch PVC. While a bit like building a ship in a bottle, it wasn't too bad to get it together.

I used 6 stainless #10 eye bolts as wire anchors and 6 stainless #10 machine screws for the terminal connectors, 3 per side.
The terminals were spaced 6 inches apart, a bit more than the 5 3/4 inch spacing suggested in the original SRI design. (It is important to remember that all 3 center insulator terminals are wired together on each side of the center insulator making each half of the dipole parallel with the other band dipole legs on the same side. Each half of the dipole is connected to the SO-239 connector. One side of ALL of the dipoles is connected to center pin on the S0-239 connector and the side to the shield side of the connector.)

The three terminals for each side were connected with 12 gauge wire with ring terminals. The nuts and washers for the middle terminals and eye bolts were held in place by putting them on the end of a long screw driver with a bit of axel grease to hold them on the tip.

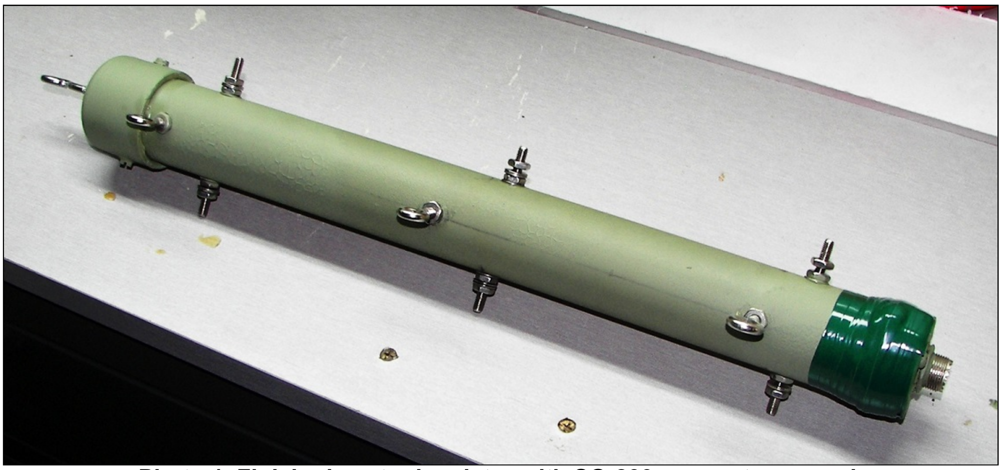
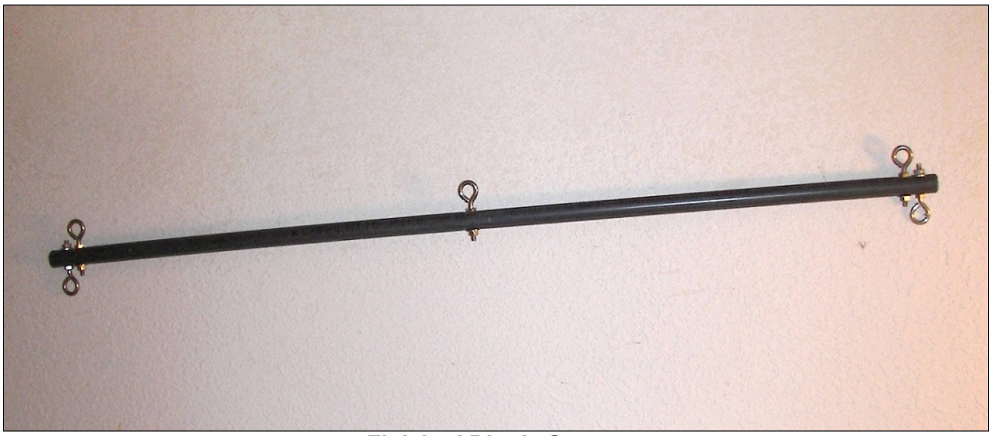


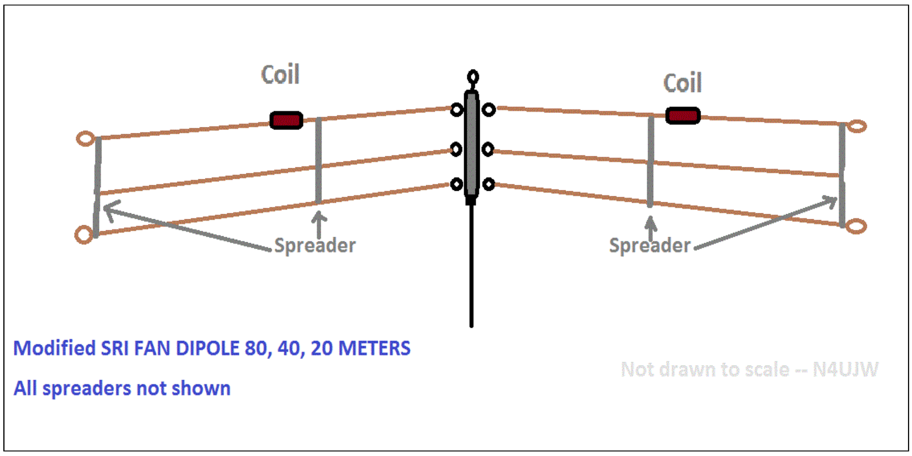
Photo 1. Finished center insulator with SO-239 connector on end.
Dipole terminals spaced 6 inches apart.



Finished Dipole Spacer

Note that the spacing between each dipole on the end spacer is 19.5 inches between each wire as suggested by the army's total length of 39 inches in the original SRI article. Although not mentioned in the article, small diameter PVC tubing can be used for the spacers (sometimes called spreaders) between dipoles or any non-conductive material.

Yellow drawn in lines represent separate dipoles with spacers.
80 meter coil is in upper right of picture.



**I built the antenna on the ground and tuned all three bands with my MFJ analyzer.
The 80 meter wire started at 45 feet per side, the 40 meter wire at 32 1/2 feet per side and the 20 meter wire at 17 feet per side.**

Starting with the analyzer on the top wire, each band needed to be shortened a bit. After about 5 adjustments all bands were resonant in the middle of the band with an SWR of 1.3 or less.

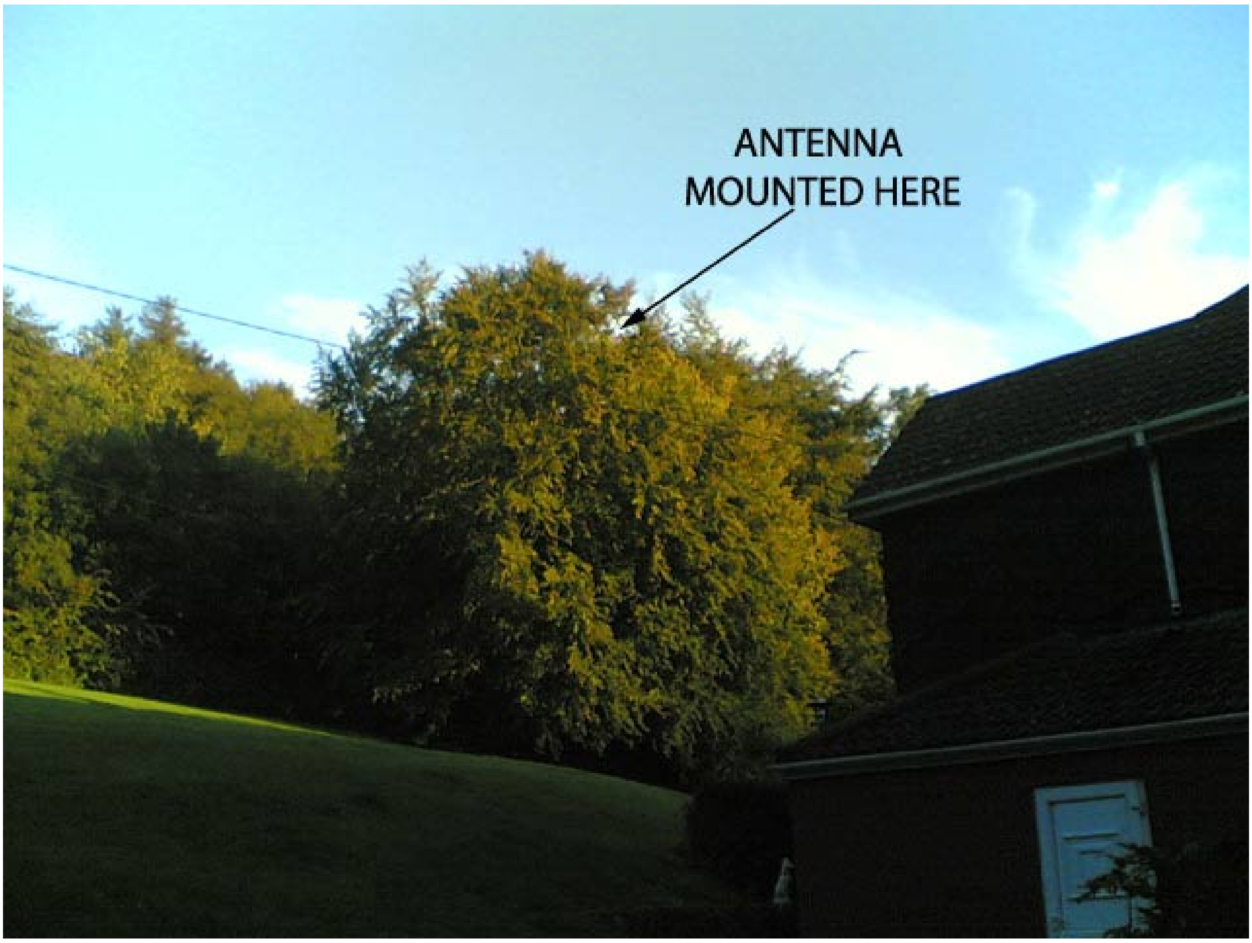
After raising the antenna up 64 feet to its final position and putting the analyzer back on, there was no need to lower it for more tuning. The same resonant points stayed as they were with SWR at 1.3 for the 20 and 40 bands and 1.8 for the 80 meter band. I have made a number of good contacts between Fairbanks and Miami with signal reports of S-6 to S-9 on all 3 bands.

I found this to be a simple and inexpensive multi band antenna to construct and I am very happy with the results.

73

Scott KL3JM
Don't forget to refer to the original SRI article on Hamuniverse.com

Email Scott for any questions here>> novak AT gci.net



The idea was put to the owner of the house would he mind a small dish to be mounted on the roof of his house - in exchange for free broadband. To my suprise *he was open to the idea!* At this point, I decided I would put the previously purchased Stella Doradus wifi mesh antennas to use...

Now a plan had to be formulated... there were a huge number of obstacles yet.. firstly I didn't even know if I could manage to obtain a solid connection between the two points. WiFi suffers huge losses over long runs of coax cable and the run from my house to the point in the tree where i could see the remote site was very long indeed.

The wireless network must be hassle free - i opted to go for linksys routers and run open source linux based software on them for maximum stability and flexibility when it comes to configuring the devices. I went ahead and purchased a WRT54G (€50).

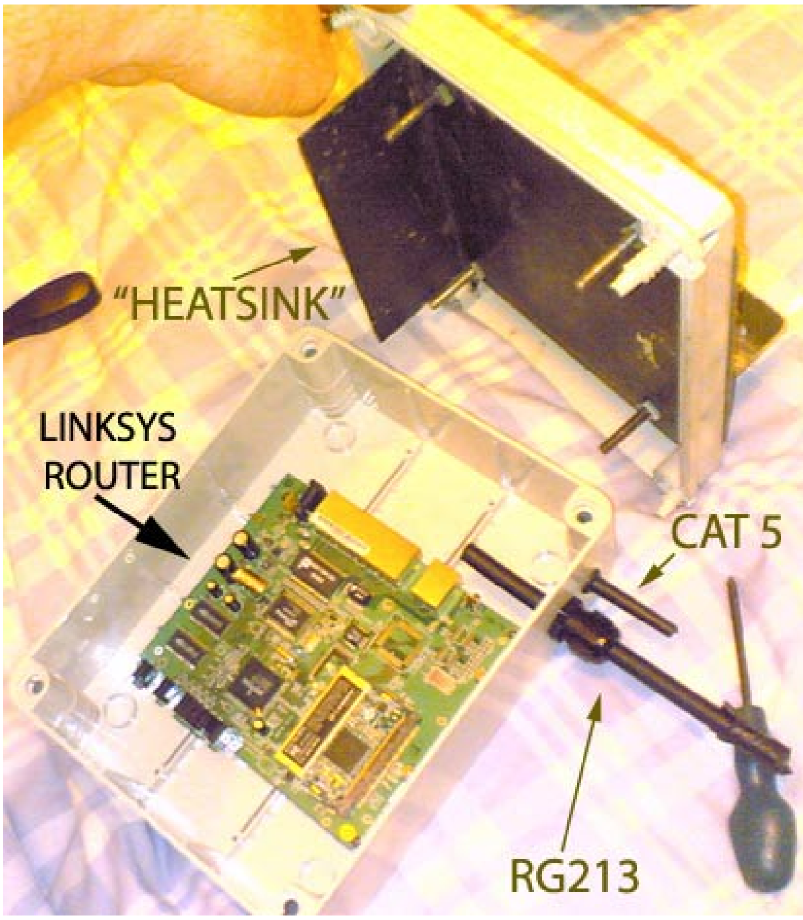
After much research I discovered the only way to get this to work would be to mount the linksys WRT54G up on the tree, powering it and communicating with it using a single CAT5 cable. CAT5 cables contain 8 strands of wire. only 4 of these are used for data exchange, leaving the other 4 redundant. Using PoE (power-over-ethernet) these 4 unused wires can be used to carry power to the device.

From my old amatuer radio days I have a large radio mast, I decided to put this to some use and erect it in the tree, using the tree as support would mean relatively hassle free erecting of the mast and the need to tie the mast to the ground with metal wires wouldn't be as much of an issue. 4 sections of the mast, each 10 foot were erected over a period of two weeks. Many branches had to be cut away in order to allow the mast to be erected in a proper vertical manner. I almost died doing this at one stage when i fell halfway down the HUGE tree only to land on a branch before i hit the ground.

The next step was to mount the linksys up the tree on the mast - this thing needs to just work without problems. A trip to maplin resulted in discovering an outdoor waterproof project box to house the router in. Along with some waterproof grommets for the cable I was ready to go. The linksys was ripped apart leaving only the circuit board and this was put into the project box. Here's how it looked after the cabling holes were drilled:

The thick cable on the right is RG213 - very high grade coax for absolute minimal signal loss. This run of cable would be a max of 1 metre to the antenna which would be mounted above the box on the mast itself.

Since the linksys would be in a waterproof box cooling would be an issue, maybe not so much in the cold winter months but definitely when the summer time would arrive. In order to overcome this a metal heatsink was created from some spare metal, the metal was welded, drilled, sanded and then bolted onto the box.



Here's the external part of the heatsink... notice the "bracket" for securing the box to the mast:

My hope was the metal plate inside the box would absorb the heat coming from the transmitter and seep out thru the bolts onto the external metal plate.

With the mast in place the cat5 had to be run from the house... my initial cable was regular indoor cat5, I knew this would not be a permanent solution because it's such flimsy cable - after some initial pains with getting PoE to work the cable was scrapped and replaced with outdoor cat5 that a friend of mine had lying around. This cable was much better - it was still and had a very strong outer plastic layer.

Using some wiring diagrams i got off the internet and some old CAT5 socket boxes the power over ethernet system was constructed successfully.

The linksys is powered by 18 volts to compensate for the power loss in the long run of PoE cat5. A test signal was successfully established without ANY problems - I knew I was now going to have a solid connection between the two endpoints. A smaller dish was mounted on the remote site's roof, and the router was installed and powered up.

I've always had my internet connection (dialup) shared using an old faithful freebsd machine ... I put another network card into this machine which I had lying around and configured a firewall and NAT to provide internet access to the machines on my LAN. **BROADBAND HAD ARRIVED!**

Thou it may not look it from the picture above.. the antenna is situated quite high off the ground:

This elevation offers direct line of sight to the house up the river at the other end of the valley, here's a view from the bottom of the antenna on the tree:

At the remote end there's another LinkSys WAG54GS (a 3 in 1 device: wifi, ethernet and dsl modem) which is connected to another directional antenna. Unfortunately the WAG54GS came with a hardwired tiny plastic antenna since linksys did not imagine this device would be used for long range applications. In order to fit the antenna the WAG45GS had to undergo some surgery - the plastic antenna was removed, the coax desoldered and a new connection soldered onto the mainboard which i robbed from another WiFi router i'd lying around the place.

I encountered several annoying problems with the setup after a few days of use. The WAG54GS which was not capable of running the open source software was unstable and seemed to lock up after a few days of being switched on. This was no good and I had to repeatidly ask the owner to restart the stupid thing. I upgraded the firmware to a blistering edge copy i found on a beta firmware linksys site which according to linksys would solve the known problem with lockups in the earlier firmware.

No such luck - the device still started locking up. During these lockups the device was pingable, but could not be access via the web interface and it would not route any traffic.

A hack type solution had to be put inplace - I setup a cronjob which performed a HTTP POST on a nightly basis which rebooted the device. and 5 minutes later enabled "debug mode" which basically just enables a telnet daemon. More weeks passed and I eventually pinpointed a potential problem - a noticed a number of UPNP daemons running on the device which seemed to consume quite alot of its tiny memory space. I disabled UPNP - this seemed to help things!

The result of all this was that I now had a stable network.. my 3MB broadband still was not performing as good as it should.. this led to me experimenting with the wireless network settings.. eventually i found the magic combination - i disabled all "automatic" style settings and changed them to fixed settings. These settings when changed (e.g. Use MIXED [b/g] wifi technology changed to Use B technology, auto detect network speed was changed to a fixed 5.5MBps) resulted in a stable transfer speed.. where I used get up to 60KB was now bursting

up to 210KB/s! A vast improvement. I also noticed a constant ping would show sporadic increases in network latency times... changing all these settings from auto to fixed values helped this anomaly too.

Finally, here's a picture of the finished product itself:

There you have it! I have broadband now and it was definitely worth all the hassle.

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About

Jerry Walsh Tech Entrepreneur, hacker, bootstrapper, biz nerd and all round computer nut. more..

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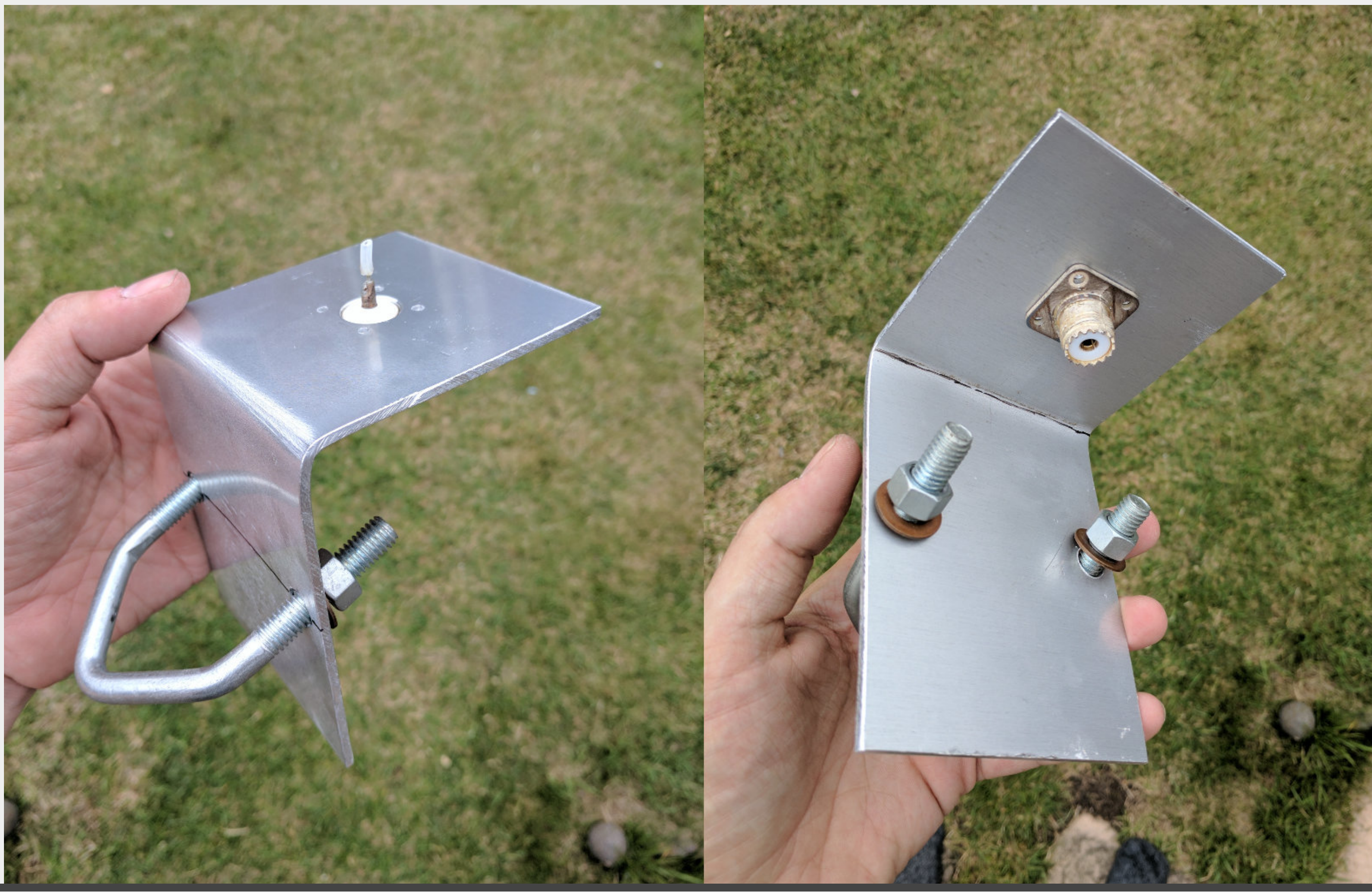
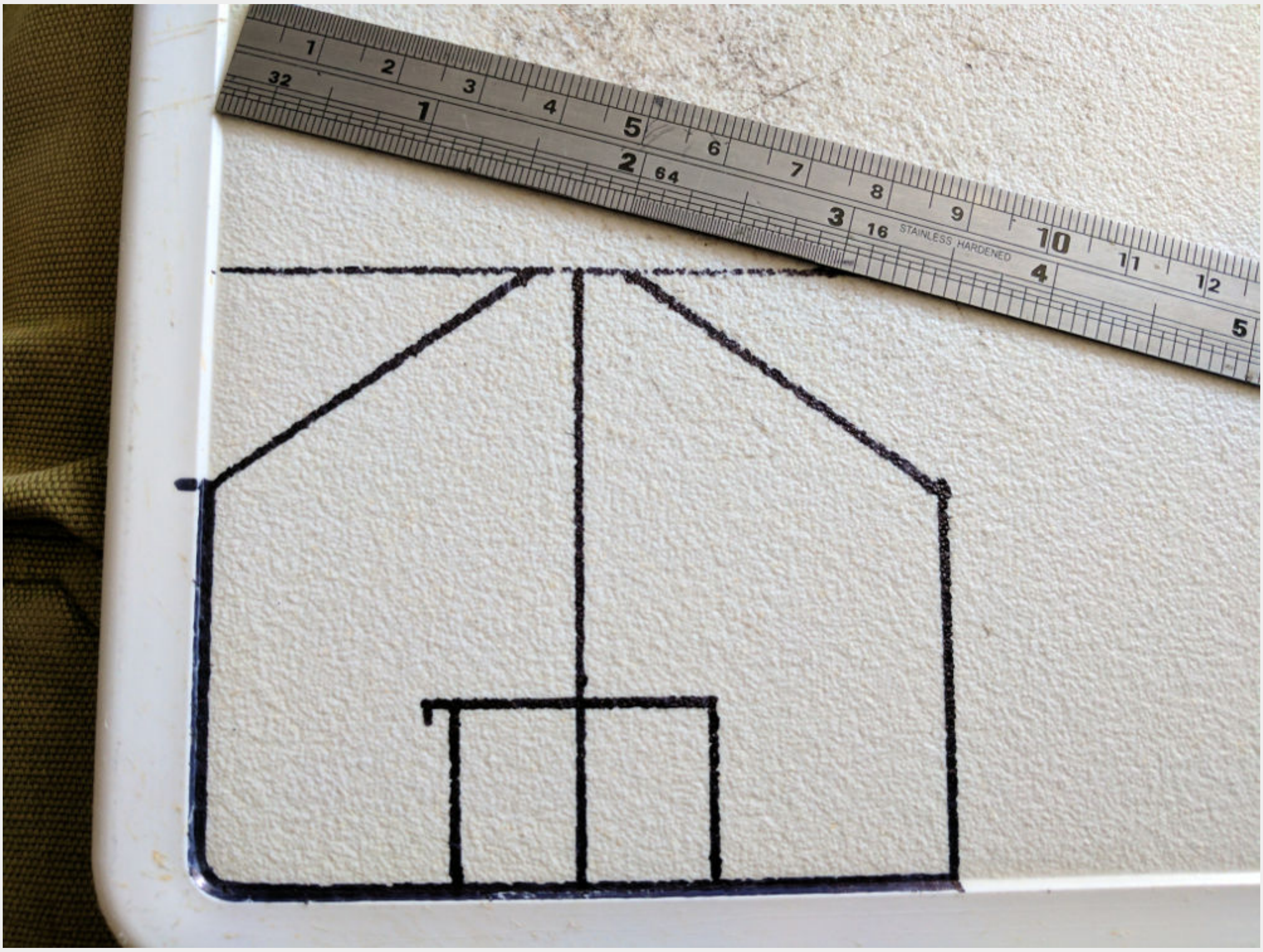
70MHz Quarter Wave Ground Plane Antenna

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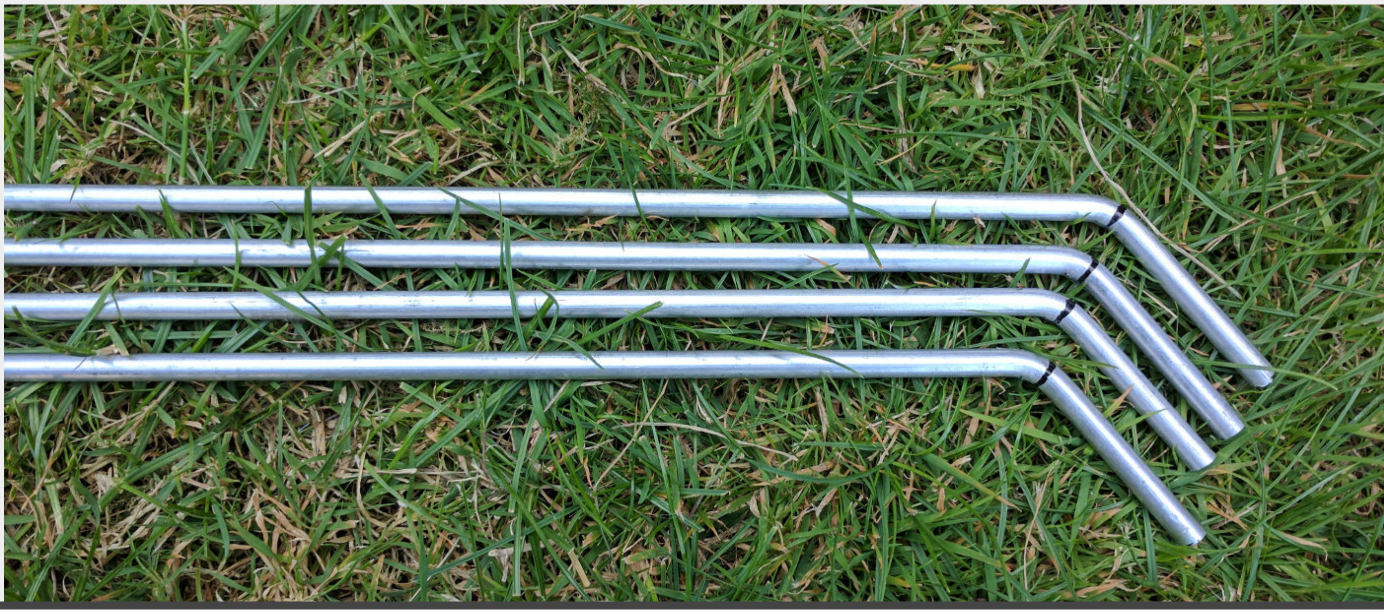

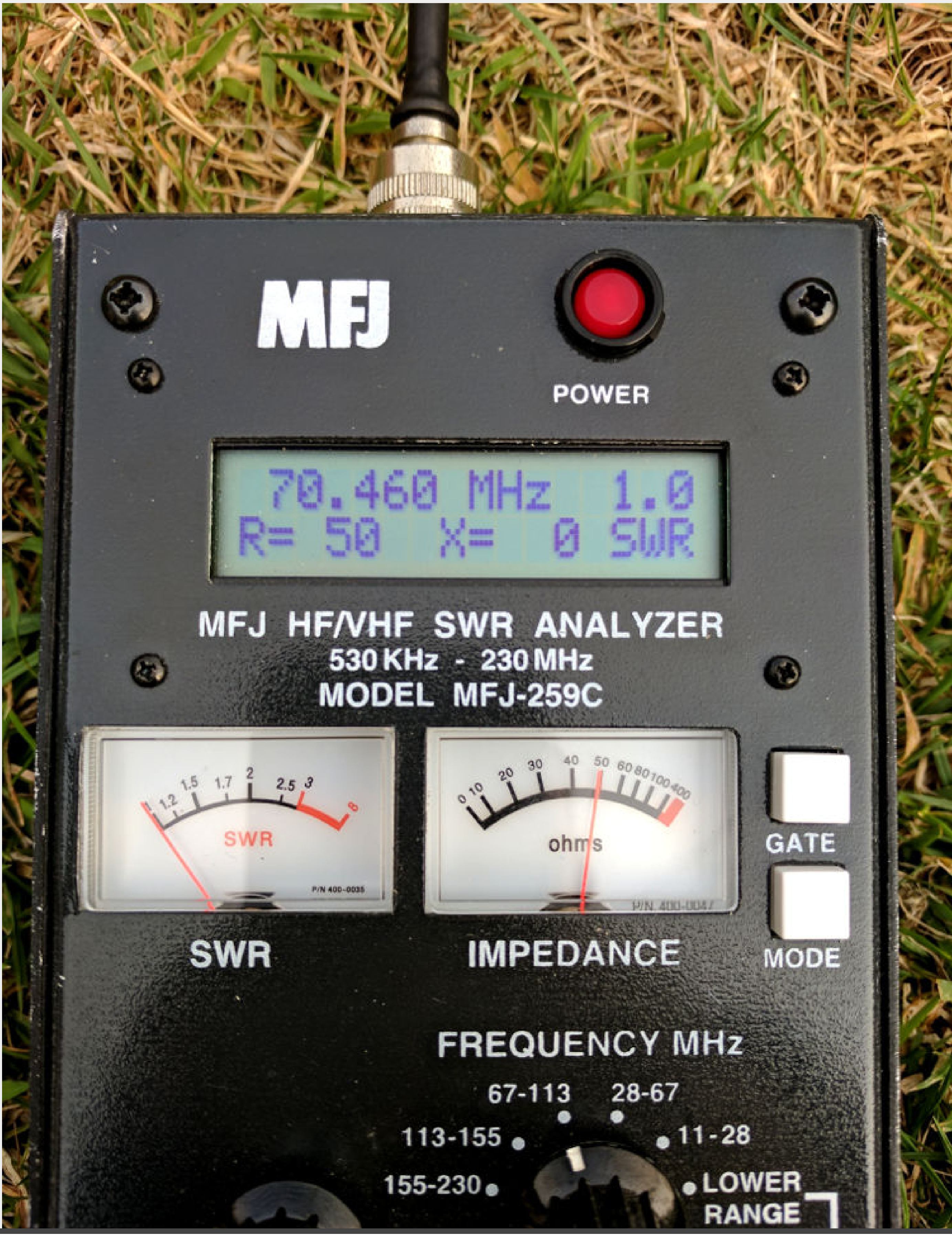
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70.460 MHz 1.0
R= 50 X= 0 SWR
MFJ HF/VHF SWR ANALYZER
530 KHz - 230 MHz
MODEL MFJ-259C
SWR
ohms
GATE
SWR
IMPEDANCE
MODE
FREQUENCY MHz
67-113
28-67
113-155
11-28
155-230
LOWER RANGE

🙂

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VERTICALS -- GOT 2?

Or how I learned to build a 2 element reversible 3db gain vertical array on the cheap!

Submitted by Bob Raynor -- N4JTE

I have stayed away from verticals for all the usual reasons, mine being I could never get one to work better than a basic dipole despite all the take off angle advantages etc. When my 40 meter EDZ blew down in a heap I was desperate to get my 100 watts back on the air in a hurry with some gain and direction capabilities.

Enter my well worn copy of ON4UN's Low Band DXing and chapter 11 on vertical arrays. This time I really read and absorbed the concept of radials and phase lines.

I have been spoiled by the luxury of being able to string up 170 ft. at 65 ft for the EDZ and also construct a 2 element 40 meter reversible quad so I figured why not stay in my own backyard for a change and see what this vertical array thing is all about.

If you are interested in getting a real 3db of gain and the ability to reverse direction instantly in a very small footprint please follow along while this die hard vertical hater learns and shares some new tricks. Also please note that I tried this type of array a few years ago with about 80 radials in the ground and it was an abysmal failure so nothing ventured nothing gained.

The Antenna;

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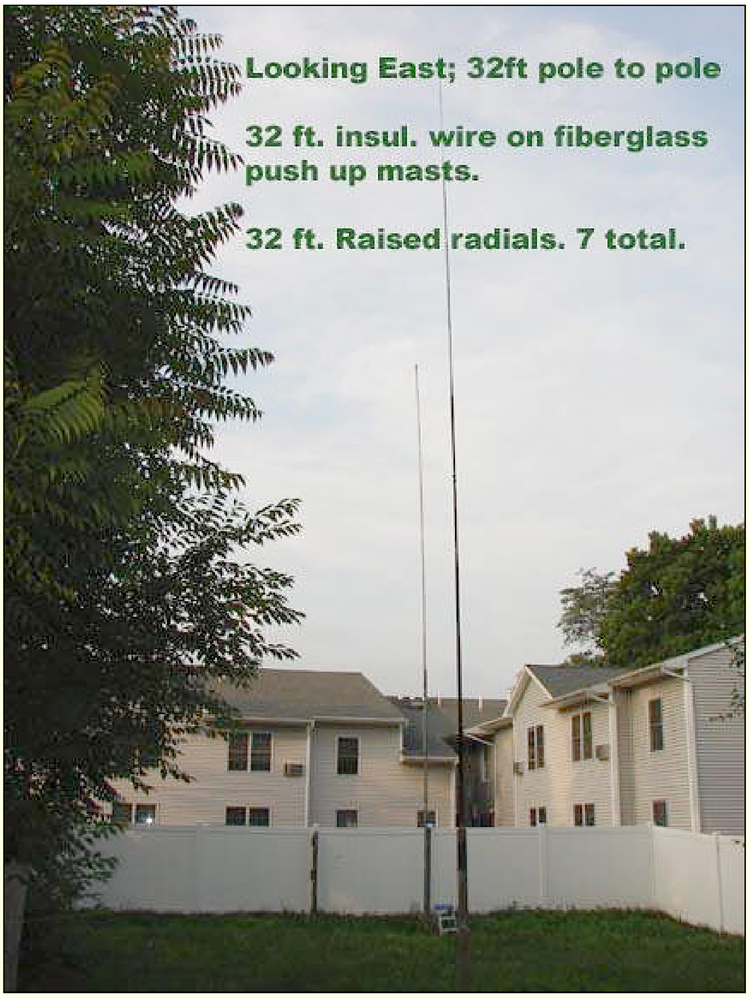
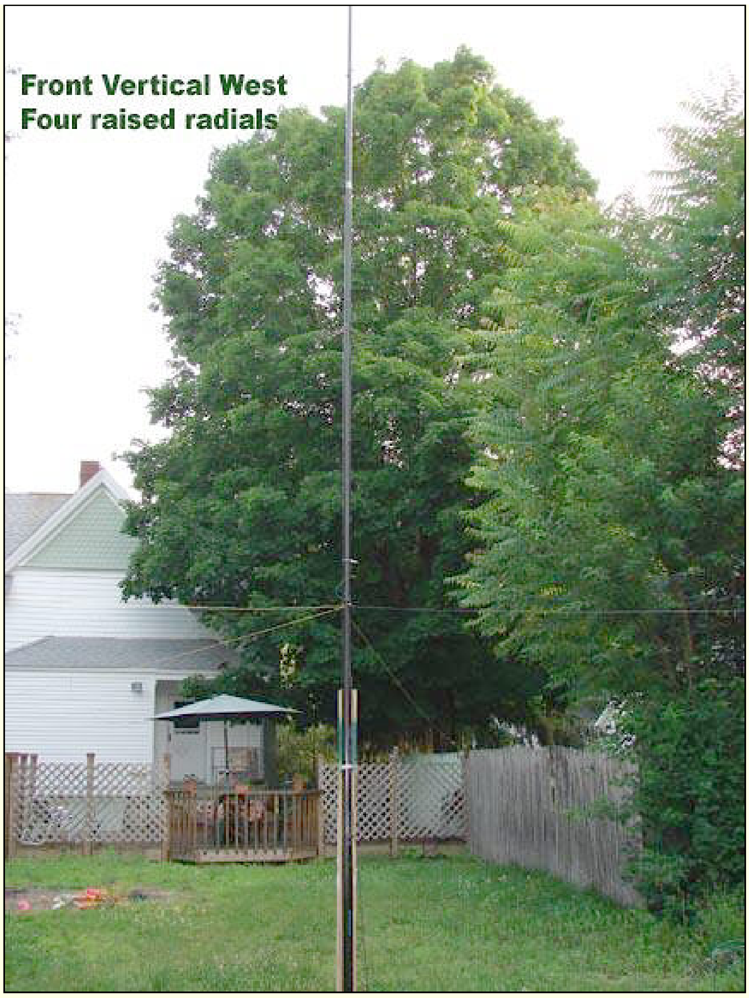


(2) 32ft. long insulated wires supported by fiberglass push up masts at aprox. 40 ft. high. Actually only one mast is the push up type the other was scabbed together using various pieces of fiberglass spreaders. By luck I have two existing 4 by 4 posts aligned sort of East/ West and about 1/4 WL apart or in my case, 32 ft. Seems like somebody wanted me to try a 2 element reversible vertical array.

The secret to my success in this venture was to use raised radials, four on the West pole and three on the East pole. The feedpoint ended up at about 8 ft high so running the radials off to 6 ft. high tie off points, (fence, trees etc.) was no big deal and easily removed if needed. The radials on the West pole are relatively symmetrical but the back pole radials are a little contorted due to lack of available space on my property line.



Construct one element at a time and set for resonance at the frequency of choice by checking for lowest swr, with all radials in place, close enough for our purposes. The ultimate goal is to achieve exact self resonance for both verticals at the same frequency. Start off with the antenna and radials the same length, in my case for 7.185 so they were 32 ft of #14 insulated wire. If

you need to adjust for resonance do it by changing the wire vertical part, leave the radials alone for the moment. Note; if you need to make drastic ie; more than an inch or two of length changes then something besides mutual loading is screwing with the settings and you might be getting thrown off by a metal fence or other structures nearby, can't help with that one.

Phase Lines; My other reason for success!

Finally figured out how to use this thing.

I've constructed and abandoned driven arrays, both horizontal and vertical, in the past because I've always felt a dual trace scope was the only way to make the phase correct but there is another way. Stick with me and wade thru the following steps; worth the trouble.

As per ON4UN's well researched specifications you will need 2 feedlines of 84 degrees and one delay line of 71 degrees to achieve the benefits of the Christman method and the force feeding of the two elements which is what gives you the gain and direction switching capabilities. All the 50 ohm coax will be cut to the correct degree length using the MFJ with a Tee connector in parallel with a 50 ohm dummy load.

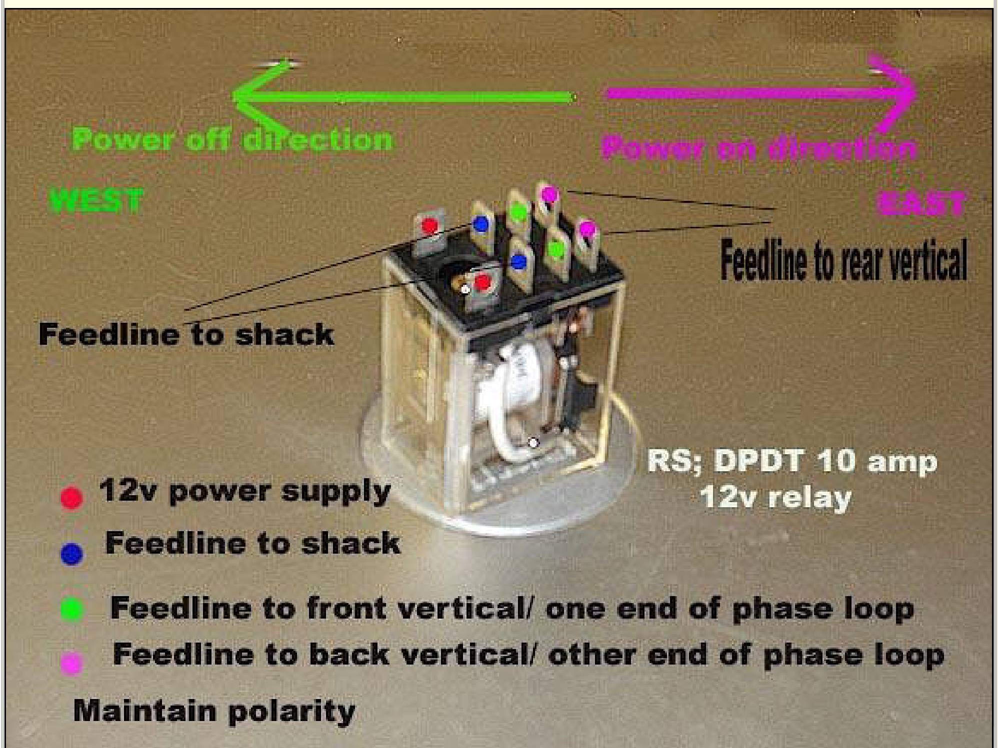
First determine your target frequency; I will use 7.185 for this discussion. As we need (2) feedlines of 84 degree length it's time for a little theory; A

true 1/4 WL (90degrees) piece of 50 ohm coax will show almost 0 swr at it's electrical length for the frequency of choice when shorted out at the end, FWI, it will do the same at the true 1/2 wl with the end left open. So we hook up a 1/4 WL length of coax based on the velocity factor and we are good to go. NOT. Trust me it NEVER works that way. Get the length that way and add a couple of feet. Attach to MFJ and short out the far end and measure for lowest swr and read the freq, in my case a 30 ft. long piece read somewhere around 6.1Mhz, way to long. Keep cutting and shorting the far end till you get to the target frequency. An ice pick through the coax is a quicker way. BUT; No matter which method this will give us 90 degrees and we need 84 degrees so it's time for a little math so we can get the correct target frequency read out on the MFJ to make the phase line SWR zero at 84 degrees, before you cut off too much wire!

***Formula**; 90/7.185 x 84/x = 6.706, gives us freq. readout for 84 degrees.*

***Verbally**; 90 degrees is to 7.185 as 84 degrees is to x, where x is the needed freq on the MFJ.*

This method will get you the 71 degree delay line length also. Leave or make all ends bare as you will be hooking the two feedlines to each vertical and the relay and also the 71 degree delay loop to the relay.



PLEASE READ CHAPTER 11-9 Fig. 11-7; ON4UN Low Band DXing for schematic.

Essentially you hook the delay line loop to each of the feedlines at the relay contacts taking care to maintain polarity. In my configuration with the relay off, the loop is leading in the West direction due to the induced phase shift. When 12 volts is applied the loop is now lagging and the direction and gain favors the East. I took a chance and soldered some short hookup wire to the relay contacts for ease of assembly to all the coax feedlines, don't imagine it makes that much of a difference on the phase lengths considering I had to cut off the connectors on the feedlines after using the MFJ for length calculations. My wiring/soldering hookup was way too nasty to photograph! This design is for 100 Watts so any higher power will of course need a larger relay.

PERFORMANCE:

It always annoys me when I read all these glowing reports from an enthusiastic antenna owner that to me are worthless unless they are well tested at various times and conditions with a couple of other antennas orientated in a similar direction. For my testing I rehung the 40 meter EDZ ladderline fed at about 50 ft. high in an East/West take off orientation. I also used a North/South dipole for further comparison. All were connected to a Delta 4 position antenna switch.

The verticals were extremely competitive with the EDZ and as the sun moved West the verticals were 3 S units louder to Ca. and the Netherlands both on receive and transmit.

The verticals had at least 4 to 5 S unit rejection in the back direction, not fair to the Zepp with gain but showed at least that much with the unity gain dipole.

I did not notice as much noise as expected with verticals unless I went East during the FB barrage here on the East coast at 9pm, I believe that a driven array is slightly less prone to nearby manmade noise.

Some of this may be obvious to the experts out there considering the lower take off angle of the verticals but it was a real revelation to me.

FINAL THOUGHTS;

I believe that any success I achieved with these verticals and none before, was due to using raised radials and cutting phase lines accurately. The added bonus of keeping it all in my own backyard and the simplicity of upkeep and pack up has made this a valuable experiment for me.

I hope this article will encourage others to explore driven arrays and research the amazing amount of reference material out there.

Resources; Relay; Radio shack #IEC255

40ft fiberglassWWW.shop.dx-is.com **Contact them atwww.dx-is.com**

ON4UN's LowBand DXing.

"MFJ" as used in this article means the MFJ 259B antenna analyzer.

Tnx for reading

Bob, N4JTE www.n4jte.blogspot.com

Editor note...For new builders of vertical driven arrays, this article may be confusing to you. If you have questions, contact the author, N4JTE, for his assistance at the above web address.

The GS3 antenna installation from the side of the van.

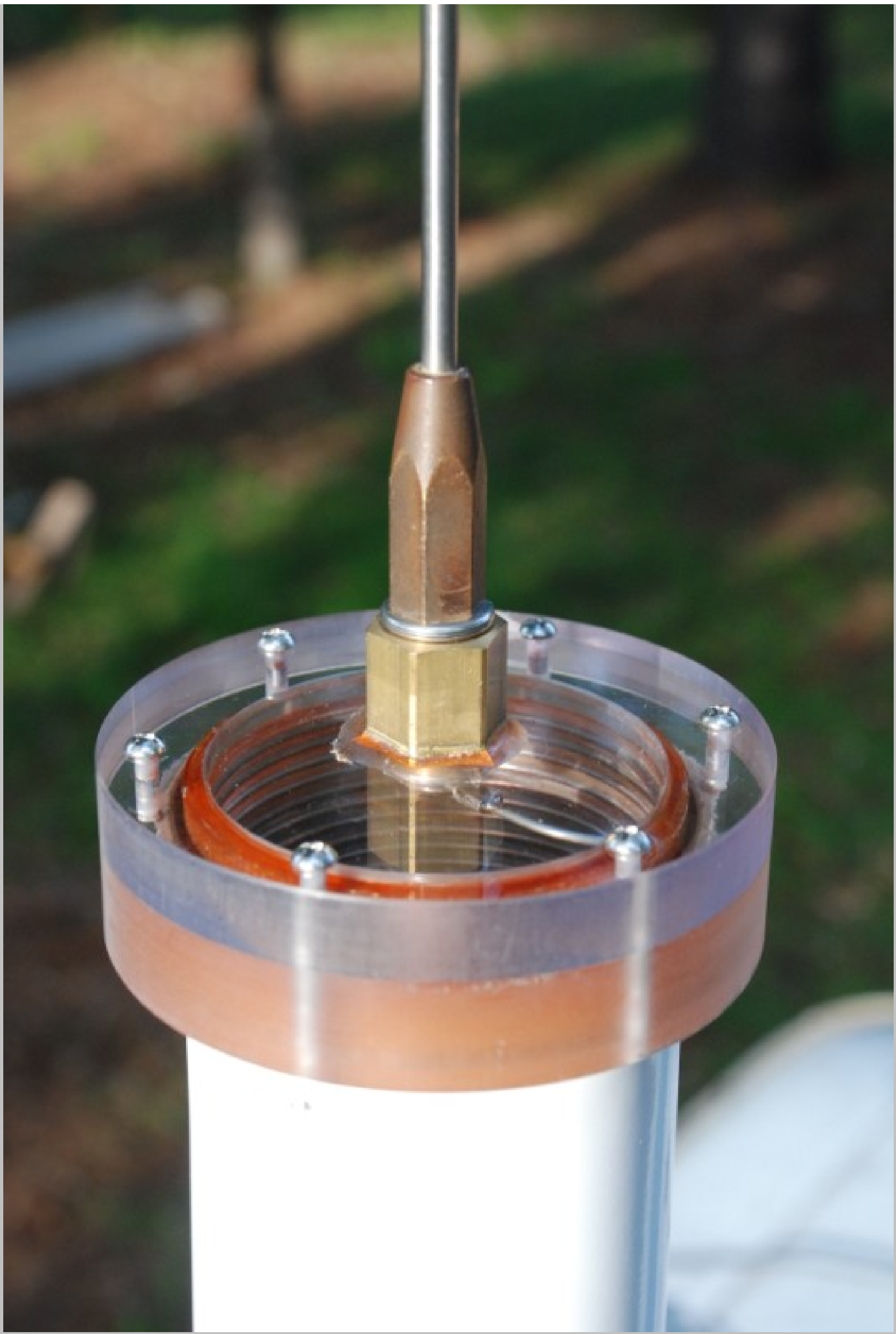
The lower base tube of the GS-series of antennas is made of a heavy gauge 2" diameter aluminum tube for strength and low RF resistance. (All the specifications for the antennas are on Gary's web site.) The loading coil is permanently and securely attached to a metal strengthening ring that is located at the bottom of the loading coil. The top whip that I chose to use with the GS3 is only 55 inches long. I needed to use a relatively short top whip to be able to have enough vertical clearance for obstructions. Ideally, the top whip should be at least a foot longer for better radiation efficiency and lower loading coil losses.

With a top whip this short, the lowest frequency the antenna will tune to is about 3700 kHz, but that is low enough for my use. (I do have a longer top whip that I can install that will allow the antenna to tune down below the bottom of the 80 Meter band.) With the 55 inch whip, the antenna requires about 1 to 2 turns of the loading coil to resonate on 10 meters. But at that frequency, the overall loss is quite low, and the antenna efficiency is fairly high. All things considered, the short

top whip is a reasonable compromise for my use. Since the loss resistance of the loading coil is so much lower than the Bandspanner antenna, the overall results are better, plus I have the advantage of an antenna that I can retune on the fly from the drivers seat of the van.

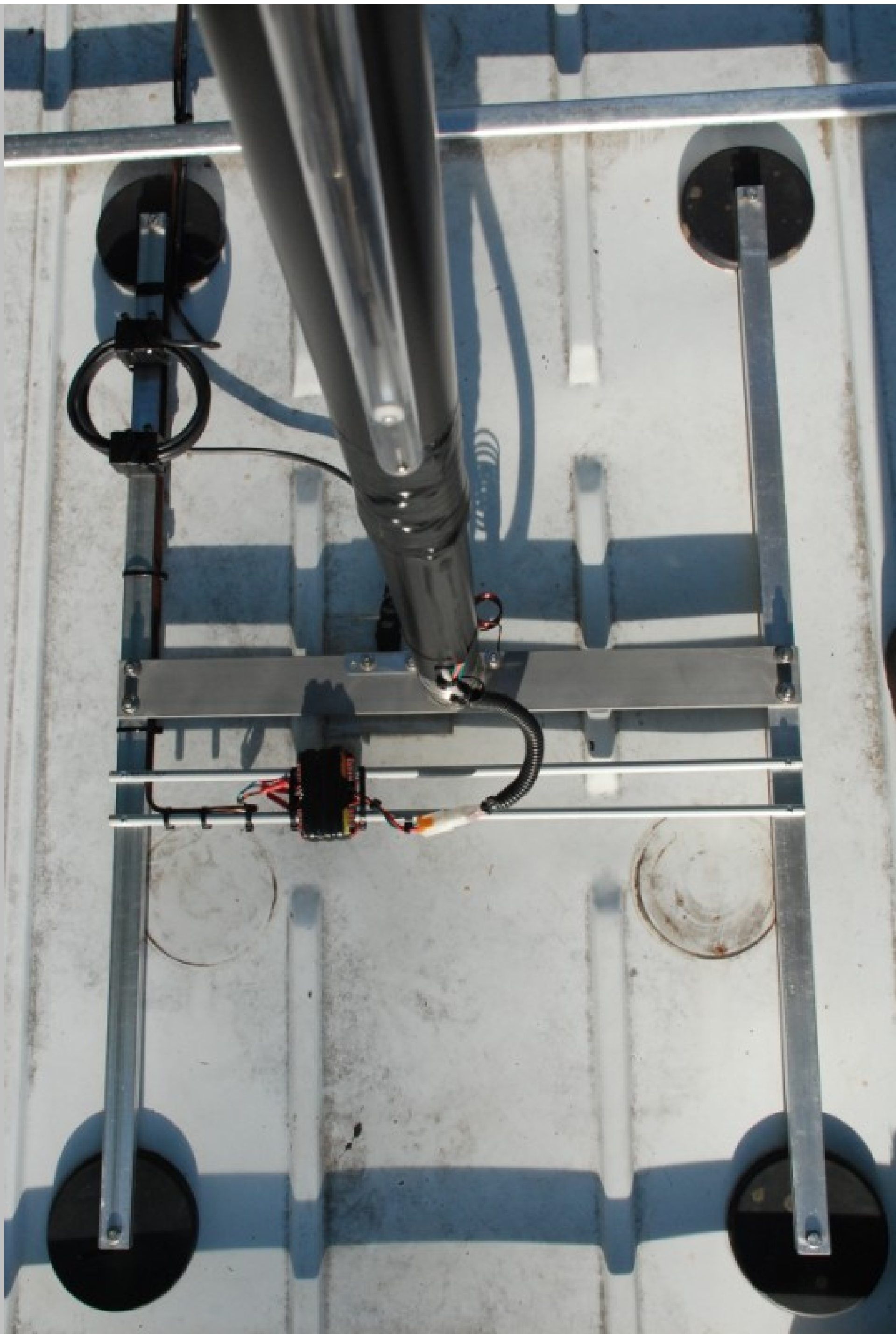
The loading coil of the GS3 antenna.

The GS3 loading coil is a real work of art. The antenna is strong enough to withstand almost any impact. The coil windings are inside the sturdy fiberglass tube, which Gary molds around the loading coil. Plastic end supports are used to eliminate the excessive RF losses that are common to many other screwdriver antennas that use metal end caps on their loading coils. Most of the RF loss in the loading coil will be at the top end of the loading coil, and Gary uses only plastic end caps at that point to minimize the losses. Gary builds his antennas as I build mine - engineering considerations first, for a better signal.



The top of the GS3 loading coil.

The topmost few turns of the 14 gauge wire loading coil can be seen in this picture. The wire is firmly and permanently embedded into the inside of the fiberglass tube. This construction protects the coil and the sliding contacts from deterioration due to the weather. A sturdy 3/8-24 thread brass fitting to accept the top whip is mounted in the center of the upper plastic coil cover. The whip seen here is one is one that I have used with various mobile installations since I had my first 1961 VW bug. It is cut for the 6-meter band, and it has survived at least five different vehicles. The base stud was originally chrome plated brass, while the whip itself is made from what is apparently indestructible 1/4" diameter stainless steel.

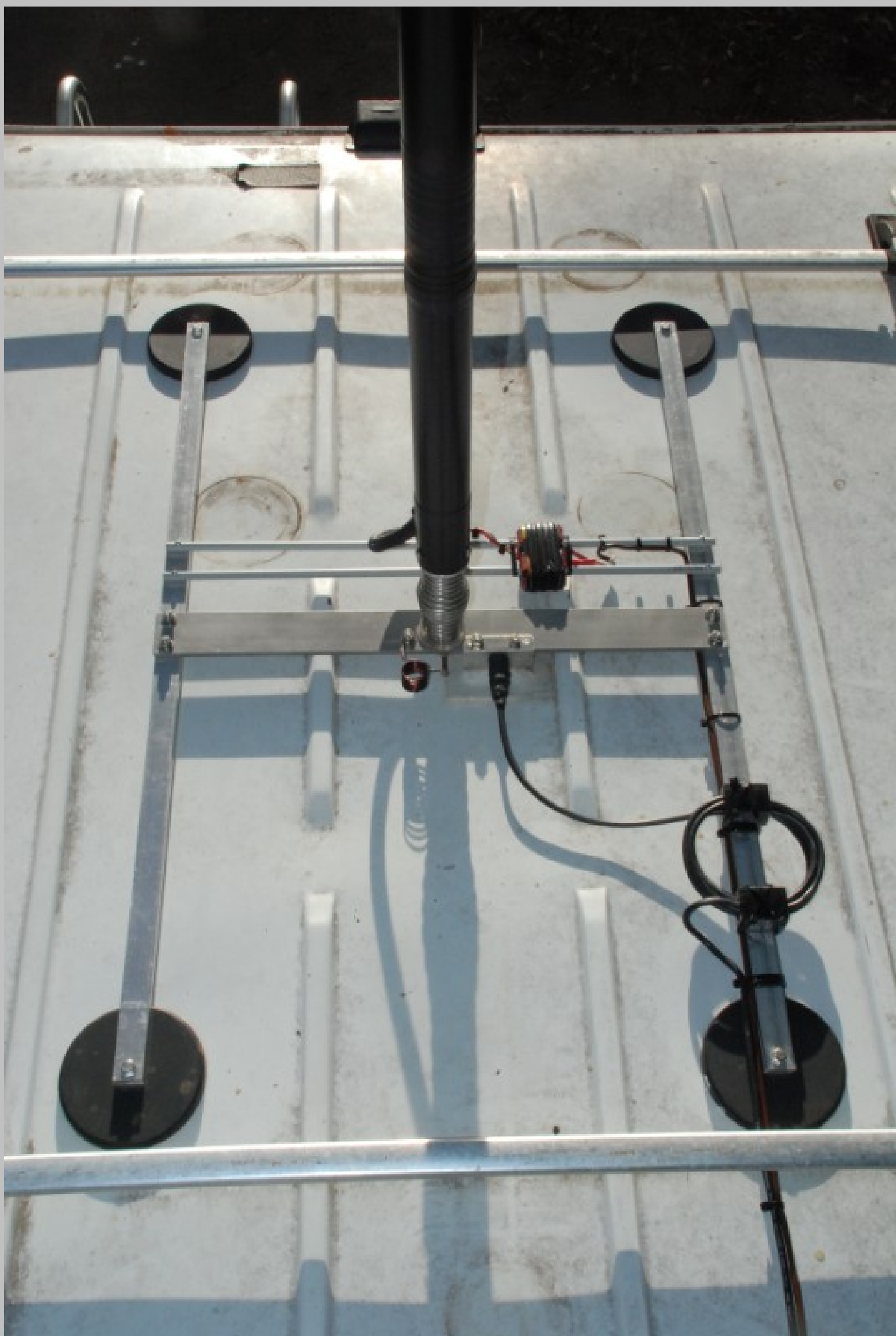


The rooftop magnet mount system as seen from the rear of the van.

In this picture, you are standing on the roof of the van looking down at the wide spaced magnet mount I constructed for this antenna. Engineering-wise, a magnet mount is not what you want to use with a mobile HF antenna. But since I have had very good results using magnet mounts on this van (probably because of the large mass of metal under the antenna) I decided to try it with the GS3 and see how it worked. I figured that if it failed to perform well enough for me, I would just drill a few more holes through the roof and install a permanent mount.

This magnet mount system was modeled after a magnet mount that I originally purchased from the Lakeview antenna company some years ago. The original design used four magnets arranged in a square pattern similar to this one but with a considerably smaller footprint. It always worked very well, and never once in over 50,000 miles of driving did it come loose from the roof. That includes the time when I had a HamStick antenna ripped from the mount when it became snagged in an overhead obstruction.

This magnet mount system uses four magnets, each one measuring 5 inches in diameter. Because the steel sheet roof of the van is fairly thick, the magnets stick extremely well. The metal bars connecting the magnets are each made of two lengths of hard aluminum stock. Each section measures 1 inch wide by 1/4 inch thick by 36 inches long. Because there are two of these strips in each bar, this gives a total thickness of 1/2 inch per bar. Making each bar from two sections of metal instead of one solid bar allows for slightly more flexibility so that as the antenna moves on the mount there is less tendency to detach the magnets from the roof of the vehicle. The horizontal plate that holds the antenna is made from 1/4 inch thick by 2 inch wide by 23 inch long hard aluminum stock. All the bolts and other hardware are stainless steel.



The rooftop magnet mount as seen from the front of the van.

In this view you are standing on the roof of the vehicle looking towards the back. The common mode RF choke for the coaxial feedline cable to the antenna may be seen near the lower right magnet. This is closest to the driver side door.

Slightly above and to the right of the antenna base spring mounted on the two parallel fiberglass support rods are the two common mode RF chokes for the motor power leads and the reed switch wires. Common mode RF is the biggest cause of troubles and tuning problems in HF mobile installations. (See K0BG's article.) You can also see the shunt coil that is mounted at the base of the antenna next to the base spring. This is required to compensate for the capacitive reactance of the short antenna at HF.

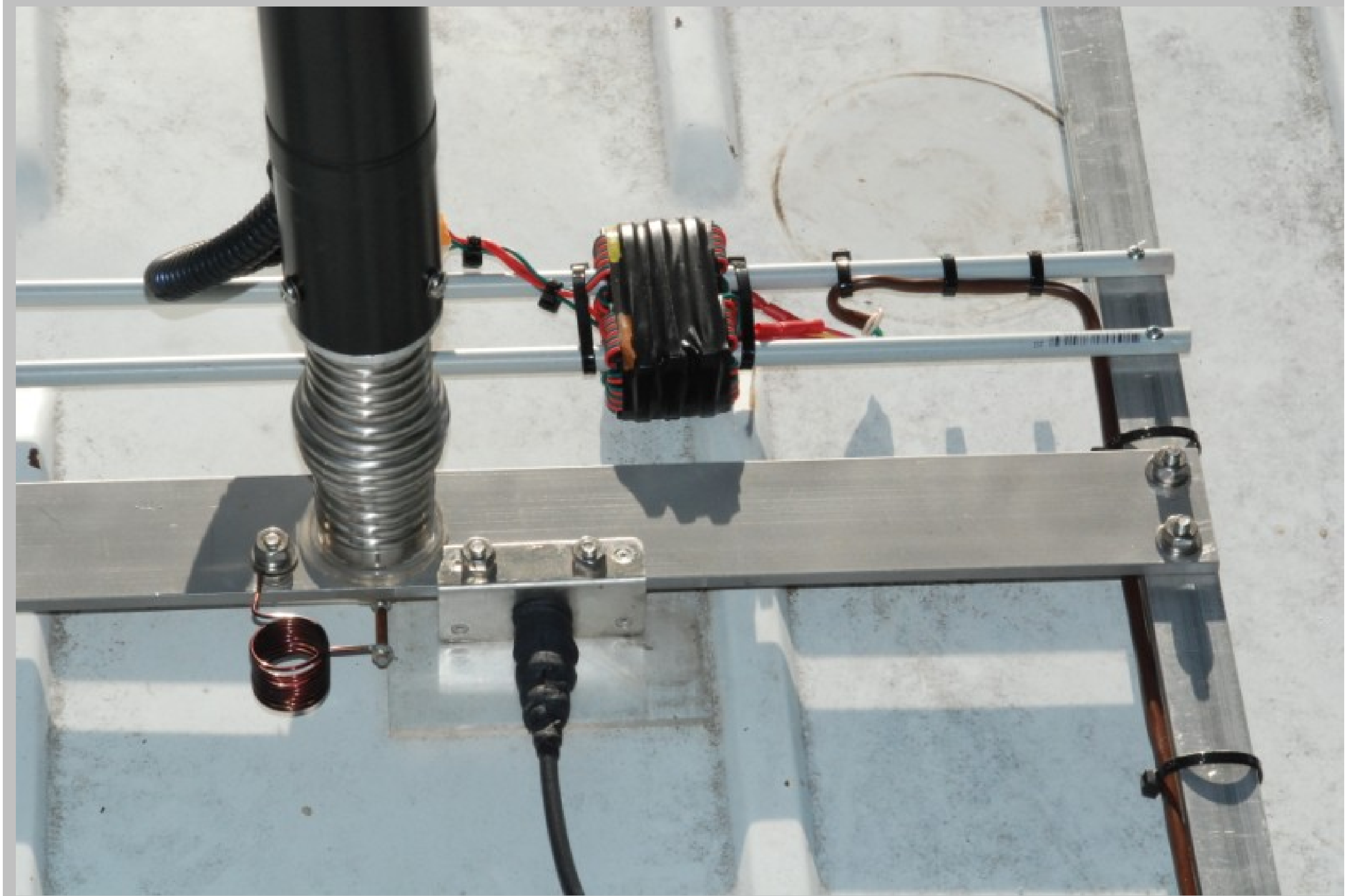
RF coax cable and control wires to inside of van and 6-meter antenna.

Near the front of the van is a quarter wave 6-meter antenna. Unfortunately the 6-meter antenna interacts somewhat with the GS3 antenna on 20 meters. The unwanted interaction occurs because the 6-meter antenna and it's coaxial cable are resonant slightly below the 20 meter band. This interaction affects the reactance of the GS3 antenna causing the SWR across of the

20 meter band to be about 3 to 1. However this isn't a real problem since the auto tuner in the TS-480SAT easily handles that much mismatch.

Below the 6-meter antenna (seen here positioned towards the rear of the vehicle) is another magnet mount. I can install a scanner antenna or a UHF antenna on this mount if needed.

The RF coax and control wires from the GS3 are fastened together with plastic ties. These lines come together with the coax feedlines from the other two antennas where they go over the edge of the roof and down into the passenger compartment of the vehicle. A small but powerful magnet is used to hold the wires for the GS3 antenna in place on the roof of the vehicle.



RF feed to base of antenna.

A small metal bracket holds an SO-239 connector for the RF feed going to the antenna. Installing a connector here makes it much easier to remove the antenna and the magnet mount from the roof of the vehicle should it be necessary. There is a small piece of 1/4 inch thick clear plastic placed between the metal bracket and the roof of the vehicle. This prevents the edge of the metal bracket from scraping the paint on the roof of the vehicle as the magnet mount flexes when the vehicle is bouncing up and down on our very bumpy country road.

When the GS3 antenna is used with a pickup truck or a sedan, it is usually attached to a fixed mount. However, I didn't think that was a good idea when the antenna was mounted on the roof of the van. I thought that mounting the antenna on a stiff spring would be a better and safer option. I had unpleasant visions of a firmly mounted antenna encountering a low hanging Oak tree branch! A base spring it would be.

The spring that I chose for mounting the GS3 is Cal-Av model MARK-5. This is a heavy spring, (Cal-Av makes much larger springs) and weighs slightly over 2 pounds. That's much heavier than your Radio Shack antenna spring. It takes a lot of force to bend it, and it works quite well with the rather heavy GS3 antenna. When I am driving, the antenna does not

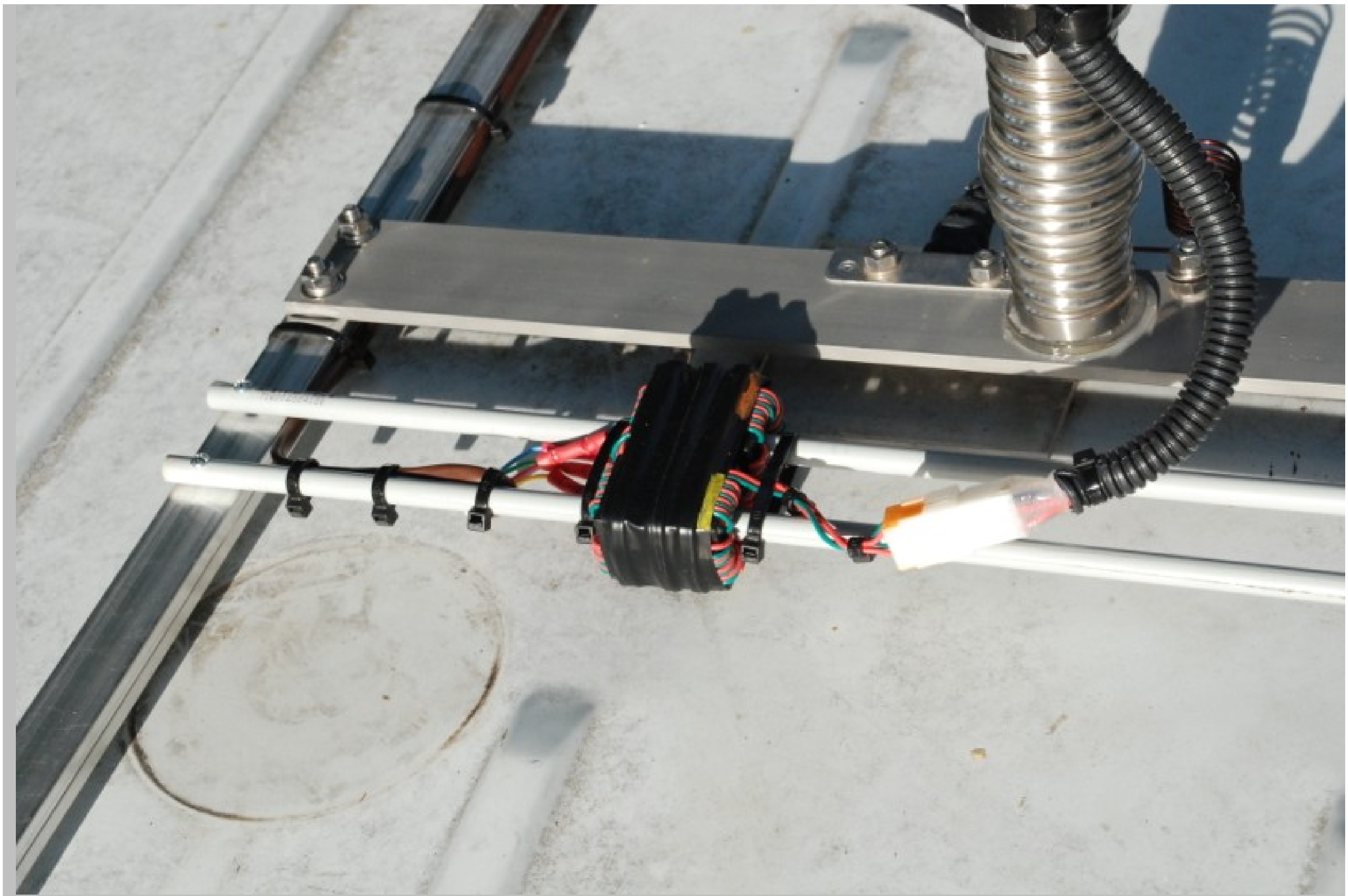
start to tilt back from the wind pressure until I reach a speed of between 45 and 50 m.p.h.. But the MARK-5 is flexible enough to still allow movement when the antenna encounters tree branches and other obstructions.

The shunt inductor at the RF feedpoint.

Gary supplies a shunt inductor to use with the GS3 antenna when you purchase his antenna, but Gary's inductor did not have quite enough inductance to properly tune the antenna on 75 meters when it was mounted on the roof of the van. I suspect that is because of the large amount of metal of the van under the antenna makes a better than usual (for a mobile system) ground plane. I made a new shunt inductor a little larger in diameter following the excellent suggestions on K0BG's web page about antenna matching. It worked perfectly, and the antenna tuned up nicely on all bands, 75 through 10 meters. I used my AIM-4170 to sweep the antenna when adjusting the shunt coil.

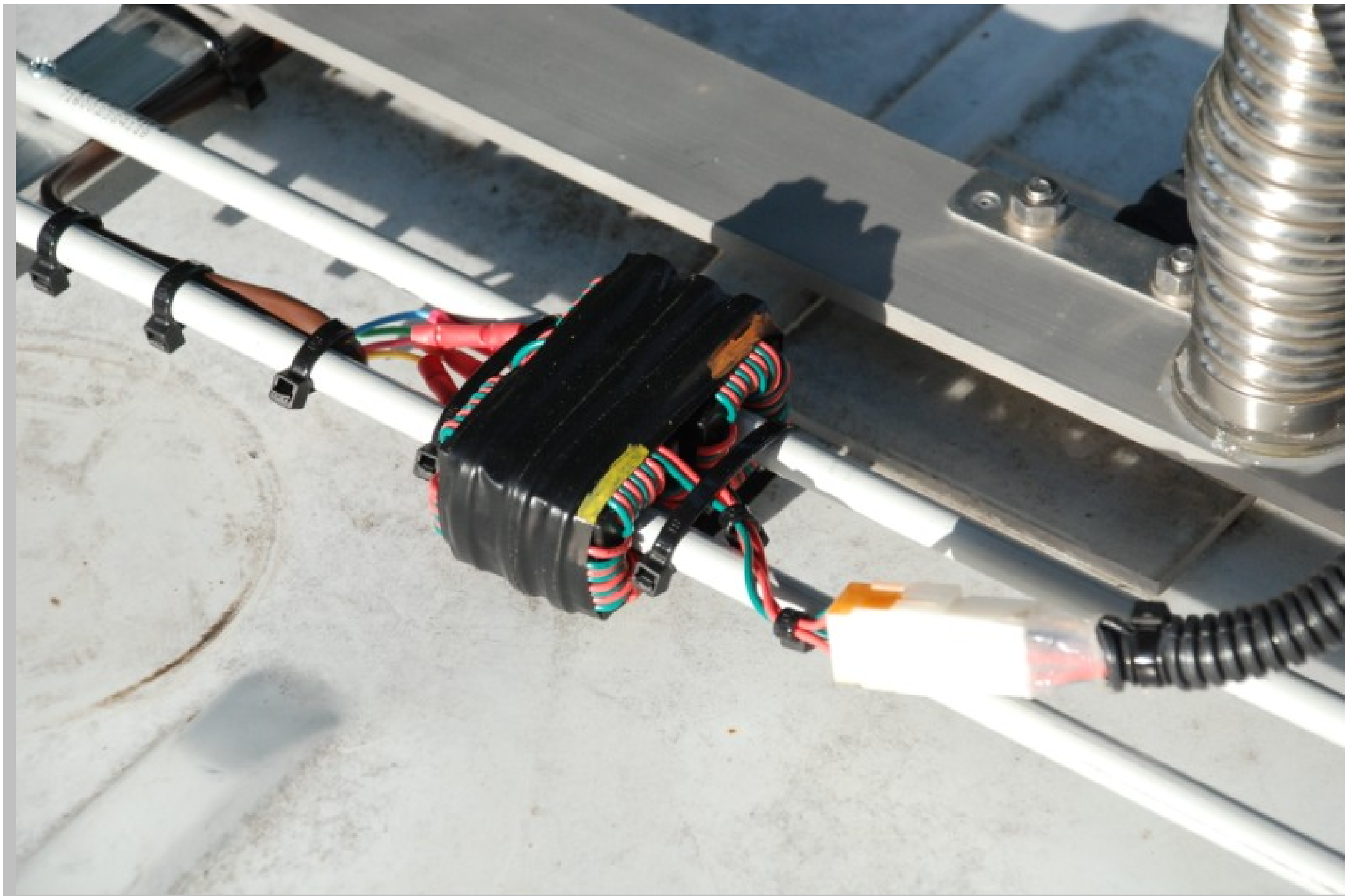
Common mode RF choke for RF coax.

To prevent RF feedback into the gear in the vehicle, it is necessary to use some common mode RF chokes on all the lines from the antenna. For the choke for the RF coax cable, I used two Mix 31 ferrite split beads and ran a total of 6 turns of RG-8X coax through the beads. That provided sufficient impedance to eliminate and problems. The ferrite beads are attached to the magnet mount support bars with plastic ties.



Common Mode RF chokes for motor power wires and reed switch.

I did the same thing with the motor power wires and the wires to the reed switch on the antenna. A single Mix 31 ferrite split bead was enough for each set of wires. There is one choke on the motor wires, and one choke on the reed switch wires. There are 16 bifilar turns of wire on each toroid. They were wound according to the directions on K0BG's web page. Because the wire in these choke coils covers the outside surface of the ferrite beads I did not want to mount these chokes against a metal surface. Instead, I mounted them on two fiberglass rods, one of which passes through the center of each choke. The fiberglass rods are fastened to the aluminum bars with stainless steel hardware. The rods themselves were cut from inexpensive electric fence support posts.



Common Mode RF chokes for motor power wires and reed switch.

The wires from the common mode RF chokes connect to the wires coming from the GS3 antenna through a Molex connector. The connector is sloped slightly downwards. The end of the Molex connector closest to the antenna is the highest end of the connector. That end of the connector is filled with silicone RTV sealer to prevent rain water and moisture from getting into the top of the connector. The bottom end of the Molex connector closest to the chokes is left open. That allows any moisture that does get into the connector to drain out. Although you can't easily see it in this picture, the end of the brown cable from the MFJ antenna controller inside the vehicle connecting to the RF chokes has the top open end of the insulation where the wires exit the cable bent over and pointed down. This is visible as a slight downward bend just past the plastic tie wrap to the left of the wire crimp splices by the RF chokes. This prevents any rainwater from getting into the cable and working its way downward and into the vehicle.

Magnetic reed switch mounting.

The reed switch that connects to the antenna controller is mounted under that mass of tape you see just below the plastic tuning position indicator cover below the loading coil.

Magnetic reed switch mounting.

It's rather a sloppy looking job, but it does work. Gary does not supply the GS3 antenna with an internal reed switch. However he did mount a magnet on the motor shaft for me, so I was able to attach a reed switch to the outside of the antenna. If nothing else, having the switch on the outside of the antenna makes it easier to change the switch when it eventually fails. There's a lot of extra tape visible on the antenna where the switch is mounted. That's because there are several wire splices and some extra wire under the tape. I tried three different reed switches before I finally found one that worked satisfactorily. The reed switch that I ended up using is a Hamlin reed switch. The manufacturers part number is 5930011766643. Eventually I'll get around to removing the extra tape and straighten out the wiring to improve the appearance.

MARK-5 base spring.

This is one tough spring! But it's what this antenna needs because the weight of GS3 without a top whip is about 9 pounds. That's a lot of antenna to have mounted on top of a spring, but the MARK-5 handles it just fine.

I left enough slack in the motor and control wires from the antenna so that no matter what the position or tilt of the antenna is as it moves around on the base spring, the wire will not be flexed excessively. I also covered the wire with some convoluted tubing for additional protection from sun, wind, and weather.

Yeah; I know - it sure needs a good wash job! Well, the van always gets parked in the same direction, and as you know, moss grows on the North side of the tree...

The coax cables from the antennas on the roof of the vehicle and the brown control wire from the GS3 antenna come down from the top of the roof over the rain gutter and into the vehicle through the door seal. What looks like a cut out in the rain gutter is actually placed there by the factory to allow rain water to drain at that spot instead of running down over the door entrance. It made a convenient place to bring the cables over the edge of the roof.

I decided the simplest way to keep the cables in place for the door seal as it closed against the frame was to use some cable ties and self tapping sheet-metal screws. This method keeps a cables firmly in place so that once the door seal has taken a set around the cables I don't get any water leakage into the vehicle.

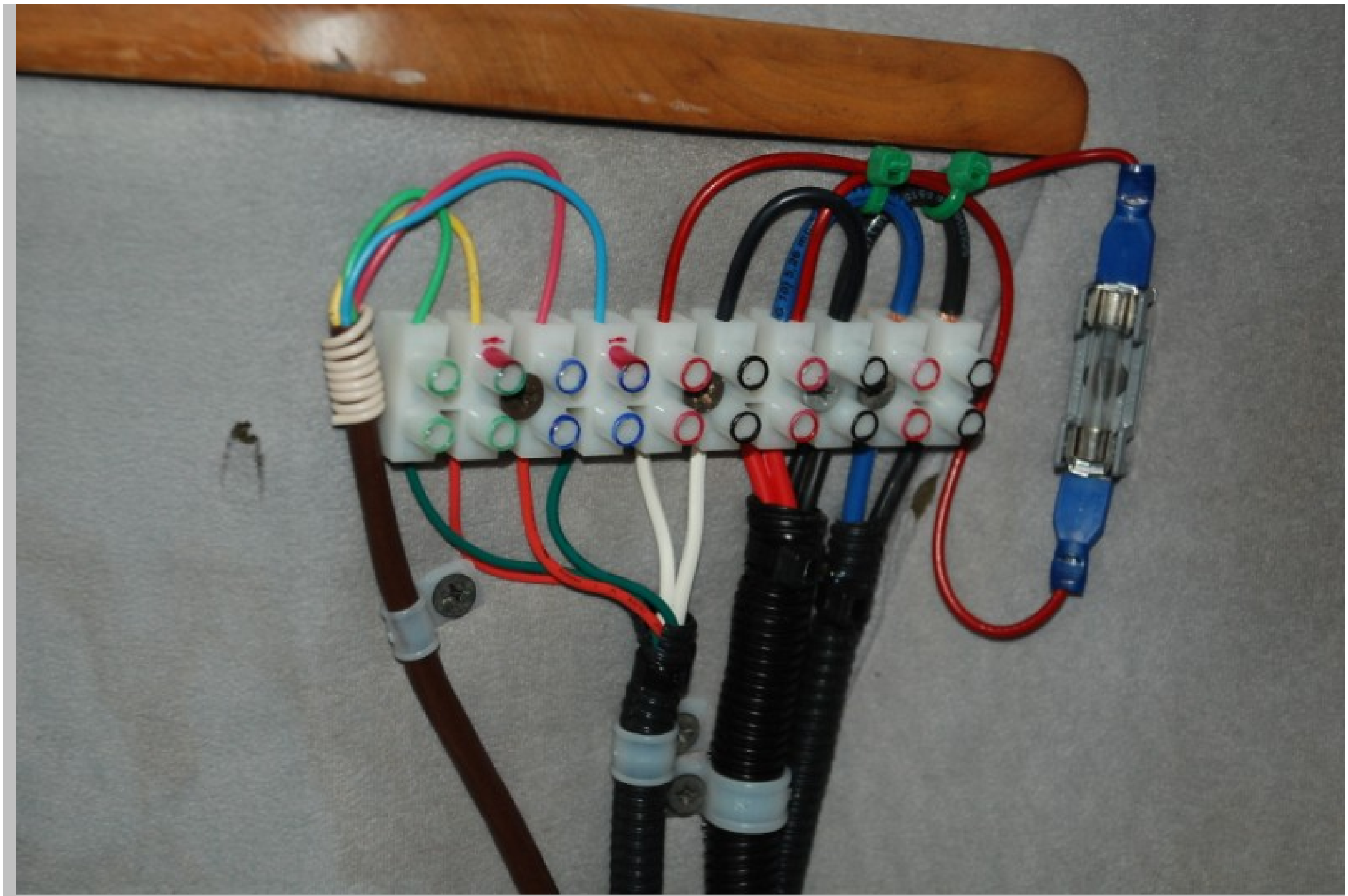
I use another cable clamp to keep the wires tightly against the door frame.

I use more cable clamps to bring all the wires straight down by the edge of the door frame.

The electronics package is a Kenwood TS-480SAT. It is anchored to the floor behind the driver seat. I used two wooden blocks to elevate the radio slightly from the carpet to allow for plenty of ventilation space. The extra cable length is coiled up and stuffed under the bottom of the radio. A terminal strip is mounted on the wall of the vehicle to provide connections for primary DC power, MFJ controller power, GS3 antenna motor leads, and the antenna reed switch.

I made a slip over wooden cover and painted it flat black for low visibility. When the cover is placed over the radio, someone looking into the vehicle from outside can't see the radio. The case has plenty of clearance space around the radio for ventilating air to get in and out. The back of the wooden enclosure is open so the cooling fans and the TS-480SAT can exhaust the hot air with no restrictions.

This is the view of the radio installation as seen from the rear passenger seat. (Note that the dog is an optional but self-installing feature of this vehicle.) The enclosure is sturdy enough that passengers can put their feet on the box with no damage.



Terminal block connections (by pairs) from left to right: GS3 antenna reed switch, GS3 antenna motor, DC power to the MFJ-1924 antenna controller, DC power to TS-480SAT, fused DC power from vehicle battery. The fuse protects the +12 V DC power line to the antenna controller.

Modified MFJ-1924 Antenna Controller

One of the advantages of a screwdriver antenna is that you can control it from the operators position. The simplest control is simply a double pole double throw switch. Flip the switch one way, the antenna tunes up in frequency, flip the switch the other way, and the antenna tunes down in frequency. This is a simple and reliable method of controlling the antenna, but it has the disadvantage that you don't have any way to tell where the antenna is tuned at any given time. You need some sort of antenna controller for that.

The MFJ-1924 antenna controller is designed to remember 10 specific tuning settings. It does this by counting the number of revolutions that the shaft of the tuning motor makes. In order to do this, the MFJ assumes that there are two things available from the antenna.

The first thing the controller needs is a contact closure of some sort, usually from a reed switch mounted inside the antenna. This tells the controller how many turns the tuning system has made. Note that this does not directly correspond to the number of turns in the coil, but rather how many rotations the tuning shaft has made. It doesn't matter though because the tuning system will make only X number of turns from one end of the tuning range to the other.

The second thing the controller needs is some way to tell when the tuning system has reached the end of its travel range. Most screwdriver antennas simply run the tuning mechanism into mechanical end stops and jams the motor when the end of the tuning range is reached. This stalls the motor and causes the motor drive current to increase dramatically. The MFJ-1924 controller is designed to sense this increase in current. At that point, the controller shuts off power to the antenna tuning motor.

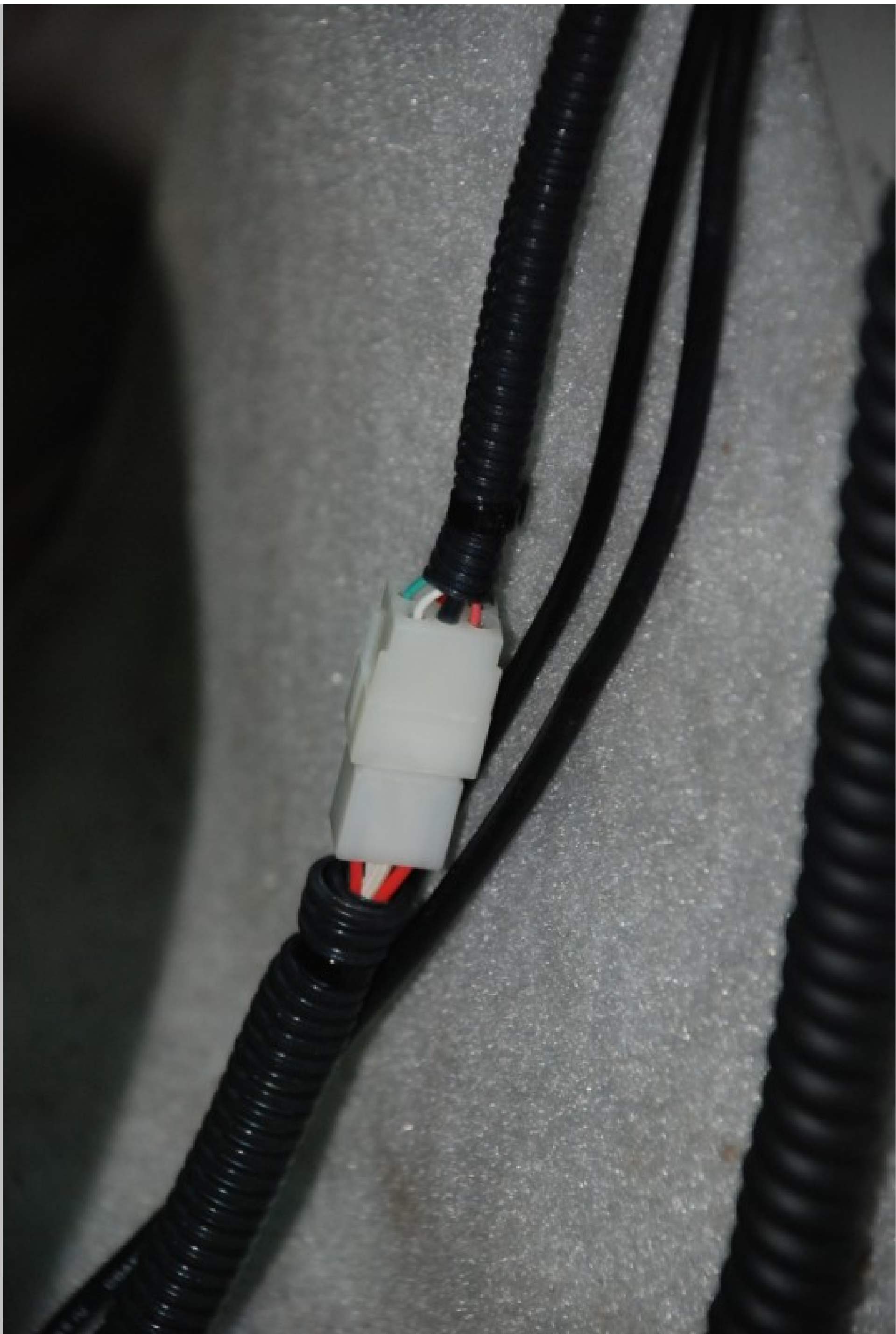
Sometimes, for reasons known only to Murphy, the controller will lose track of how many counts have gone by. For this reason, the MFJ controller has a function which enables you to "bottom" the antenna. This function tunes the antenna to the lowest frequency, stops the drive motor, and then zeroes the turns counter. So far, so good. It looks like the MFJ-1924 antenna controller is just what I need to control the GS3 antenna. Well, it was, almost.

First problem - no reed switch in the GS3 antenna. That one was fairly easily taken care of. Gary had already installed the magnet inside the antenna, so all I had to do was to mount a reed switch on the outside of the antenna, run the wires down the lower mast of the antenna, and then run them through a common mode RF choke.

Second problem - no stalled motor current for the controller to detect. In order to protect the tuning motor in the GS3 antenna Gary builds in a slip clutch arrangement. That means that when the antenna tuning mechanism reaches the end of its travel, the motor will continue to revolve but the tuning mechanism stops moving. Unfortunately for the MFJ antenna controller, this has the disadvantage of not allowing the tuning motor drive current to increase very much above the normal running current. The advantage is that it is impossible to damage the tuning mechanism or burn out the drive motor by running it into the end stops. I found that I was unable to get the MFJ controller to sense the end of travel of the tuning mechanism. I even went as far as to dig into the MFJ's internal circuitry and increase the sensitivity of the drive current detection circuit, but in the end, I found that there just wasn't enough difference in normal tuning and end of travel motor current to make the controller work reliably.

The solution ended up being a combination of electronics and brain power. I made a slight modification to the controller. Now, when I need to reset the controller and "bottom" the antenna and zero the counter, I place the MFJ controller in its counter reset mode. This starts tuning the antenna to the lowest frequency position. Meanwhile, I sit quietly and listen until I hear the "thunk-thunk-thunk" of the drive mechanism slipping when it reaches the lower end of the tuning range. Since the antenna is mounted on the metal roof, the sound is quite audible. At that point I press the little Magic Button on the bottom of the controller.

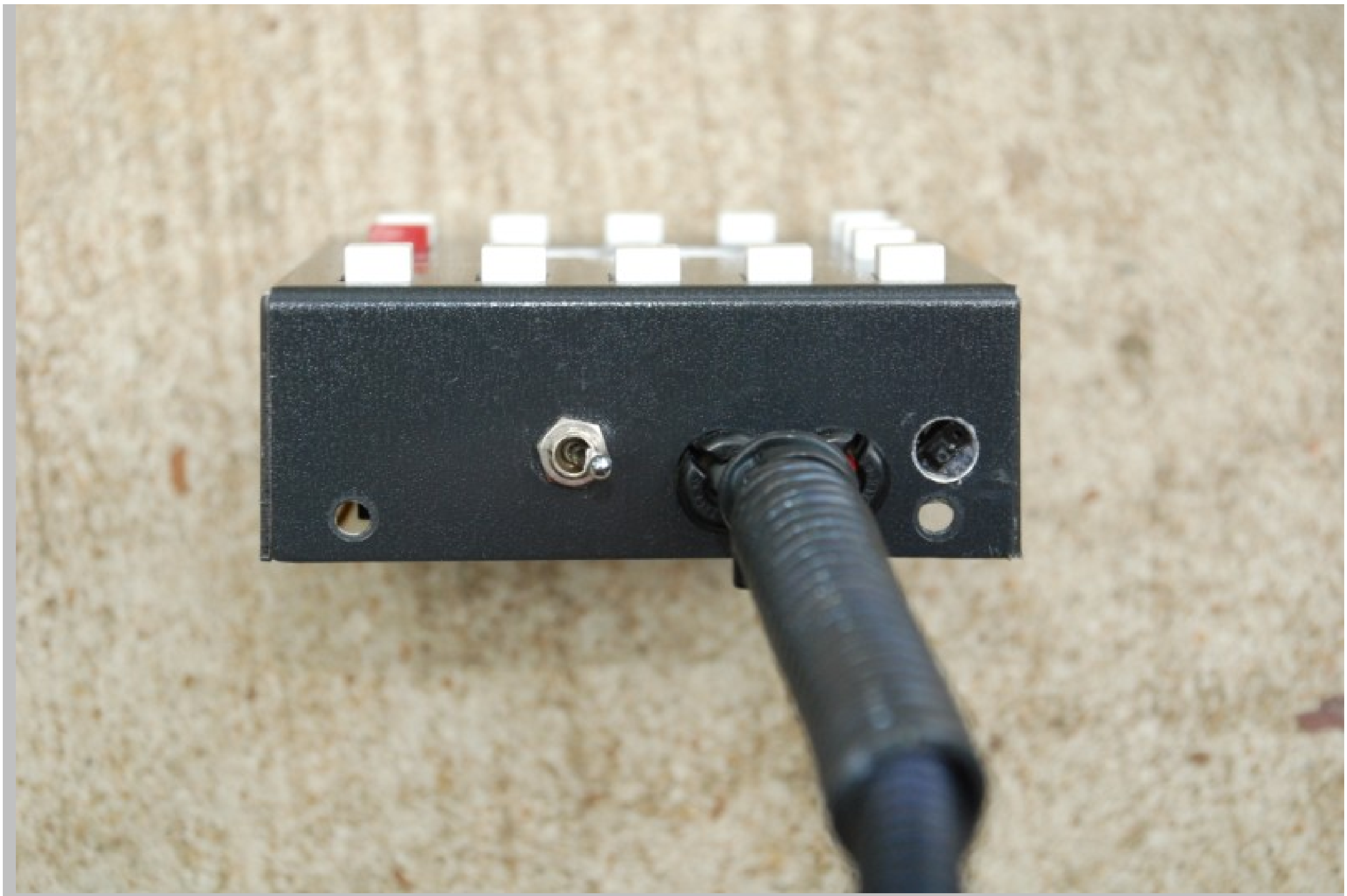
I drilled a small hole in the bottom of the controller case and installed a normally open push-button switch. I have the switch button protruding just slightly out of the hole so it can't be pressed accidentally. The switch is connected in series with a 50 ohm resistor. The resistor and switch were then wired directly across the tuning motor wires coming from the antenna controller. When the button is pushed, current flows through the resistor from the output of the MFJ controller. This extra current is added to the current being drawn by the tuning motor. This makes the MFJ controller "think" the motor has reached the end stop and has stalled. This tells the MFJ controller to turn off the power to the tuning motor and reset the counter to zero.



I knew I would have to take the MFJ antenna controller out of the vehicle from time to time, so I installed a Molex connector on the wires coming from the controller.

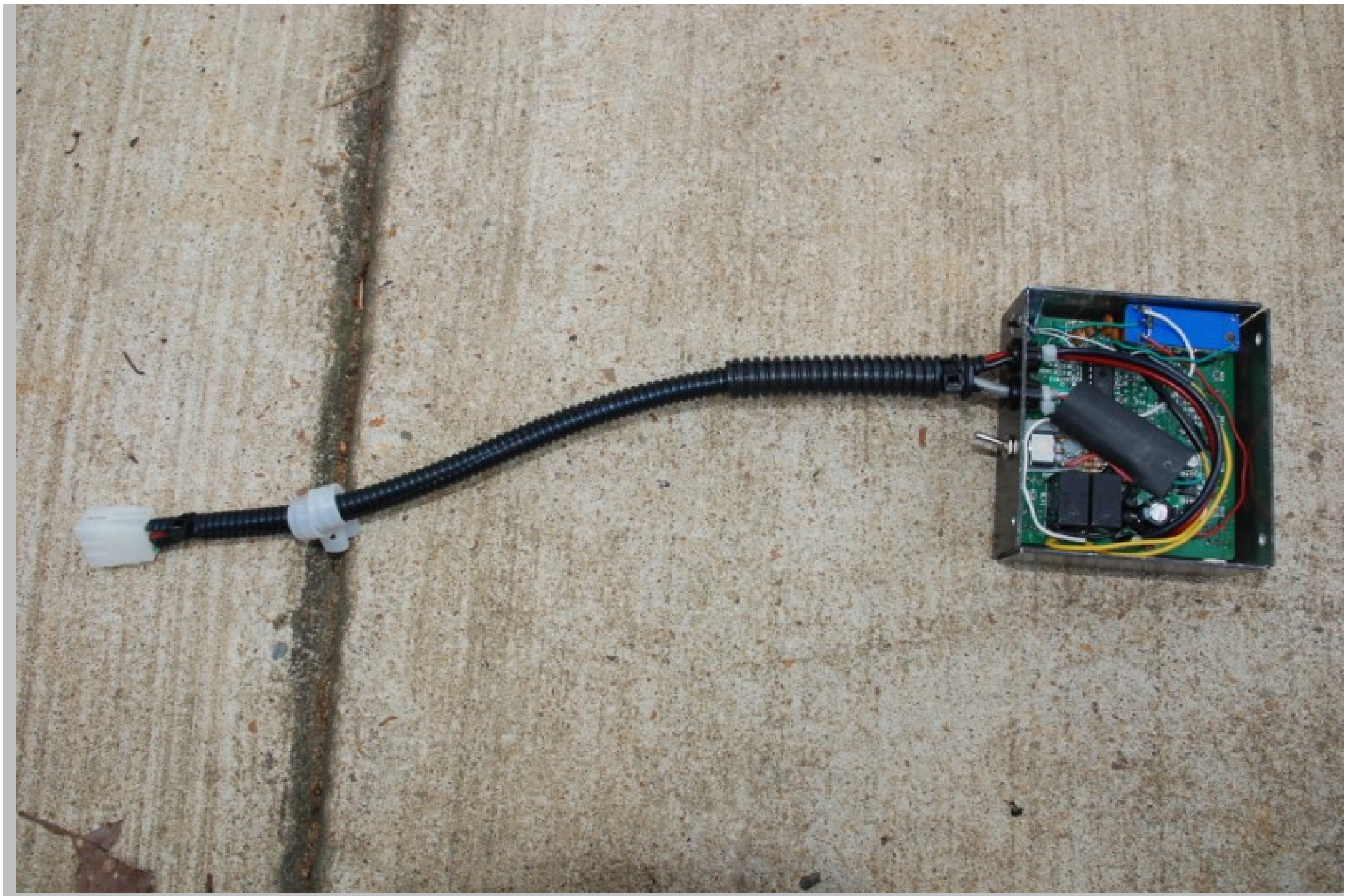
This is the mobile installation as seen the driver seat. Everything can be easily reached with one hand without stretching.

I used several cable clamps to secure the wires from the MFJ antenna controller. The controller itself is mounted to the vehicle with some adhesive backed high-strength hook and loop fastener material. The open spot in the dashboard is for the vehicle entertainment radio. I pulled the old radio out while I was doing the installation of the ham rig. I have a new entertainment radio ready to install. It will replace the old one which was killed by a nearby lightning strike. <!>

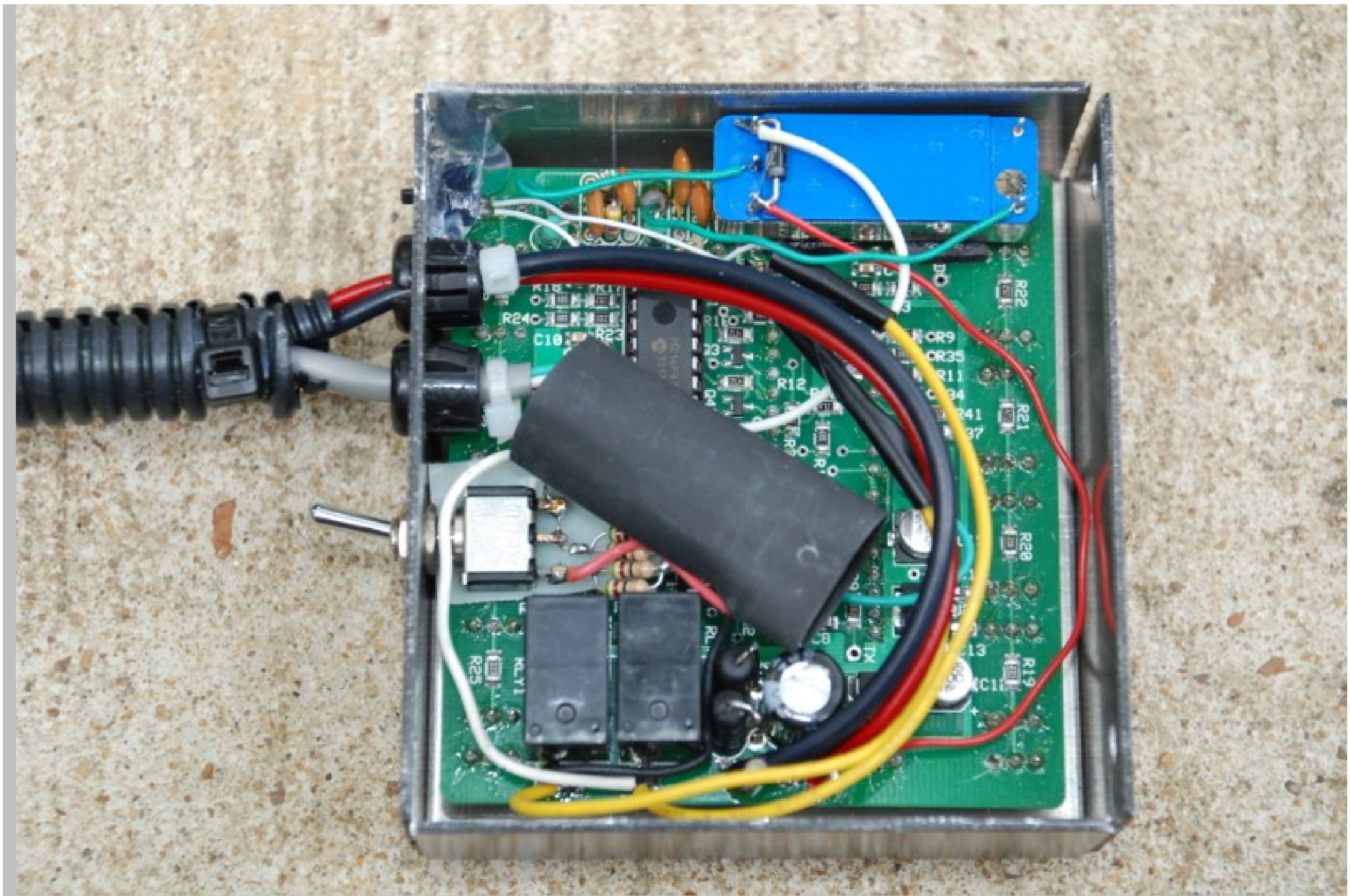


Here is a bottom view of the modified MFJ-1924 antenna controller. The Magic Button is at the far right of the controller. The switch was salvaged from a computer, and it's held inside the case with a blob of hot melt glue. Not fancy, but it works.

The silver switch is a single pole double throw switch. It inserts a 50 ohm 1 Watt resistor in series with the antenna tuning motor power wires. This cuts the speed of the drive motor by approximately half. If I need to tune the antenna manually, I can slow it down by using this switch. That makes it much easier to "tune by ear" if I need to tune to an odd frequency that is not programmed into the controller. It's also very useful if I am driving and want to manually change frequencies. I don't have to take my eyes off the road to adjust the antenna.



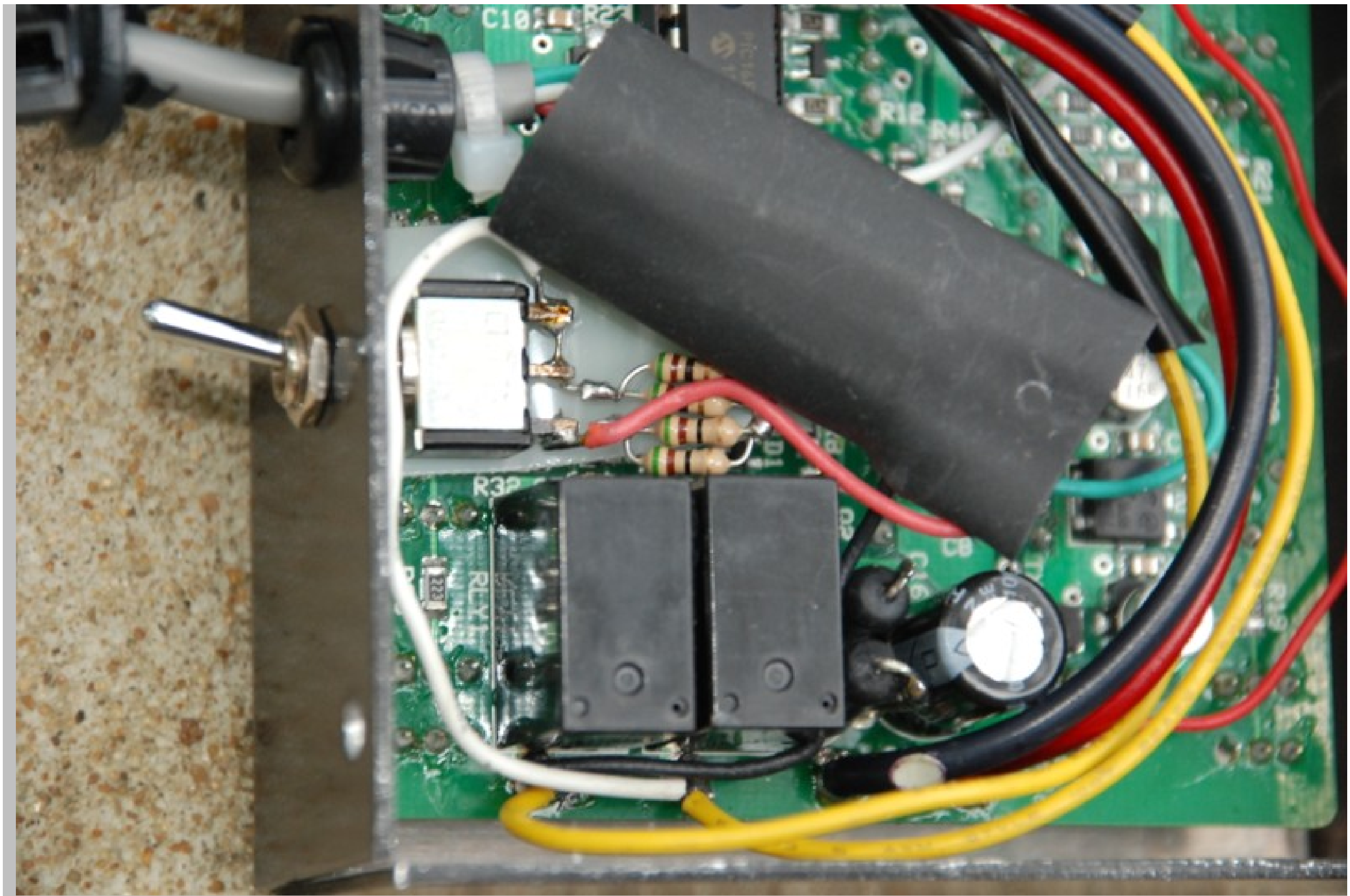
Here is the MFJ-1924 antenna controller after my modifications to it. After installing the Molex connector on the end of the wires, I use some convoluted tubing for protection. Hmm... I see a Blue Box inside the controller. That's not standard; I wonder what it's for?



At the top left of the picture is the Magic Switch. It is pretty well buried under the blob of hot melt glue I used to hold it in place. Above the two black motor control relays you can see the extra toggle switch I installed to change the motor speed.

Oh, the blue box? That's a relay that I had to install to make the controller happy. It turned out that the MFJ controller occasionally missed counts from the reed switch. This caused the tuning to be off by a turn or two very often, resulting in a higher than desired VSWR reading. I spent some time looking at the reed switch pulses with an oscilloscope, and although I did not see anything wrong with them, the MFJ consistently miscounted. Installation of various types of RFI filters and RC networks failed to resolve the problem, which happened whether or not I was transmitting..Finally I decided that the CPU in the controller must be very sensitive to the rising and falling edges of the switch pulses. Perhaps adding a relay would fix the problem. Taking another page from K0BG (scroll down to the "Debouncer") I tried a small 12 volt relay and found that it did help resolve the problem. It was almost - but not quite - perfect.

Digging into my NOS parts junkbox, I found a Mercury wetted reed relay. (Sorry OSHA & RHOS) I managed to stuff it inside the MFJ controller. I took the relay coil DC power from the switched +12 volts DC, so as not to have a constant drain on the vehicle battery should the reed switch stay in the closed position at the end of the tune cycle. After installing the relay, the problem of miscounts went away. Perfect! I just have to remember that the controller - and the relay - must be operated in an upright position or the Mercury will roll around inside the relay and short out the relay contacts, resulting in no count pulses. I figure the reason this relay works so well is that unlike a normal relay, a Mercury wetted relay has virtually no contact bounce. Once the contacts close, they stay closed, and when they open, they open cleanly.



Because I didn't have a 50 ohm 1 Watt resistor on hand, I made one by connecting a total of 4 - 50 ohm 1/4 Watt resistors in a series parallel combination.

Build yourself an RF Ammeter

by W5JGV

An Easy way to Monitor RF, AC or DC current with one Instrument

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While I was working on my 166.5 KC transmitter, needed to be able to read the RF drive to the final PA stage. To do this required an RF ammeter that could read down to 100 ma with reasonable accuracy. A search of my Junque Box came up empty, and the great floating Hamfest, eBay, didn't offer any hope either. I decided the time had come to make my own RF ammeter. As it turned out, this was a 30 minute project.

First, I needed a suitable meter. My recent search of my Junque Box had uncovered a likely candidate for conversion as seen below.

Well, the meter range is about right - the reading of 100 ma that I need to see is easily readable, and the full scale reading of 1 ampere would make the meter usable for testing with higher powered gear. But, since the DC meter cannot read RF, what to do?

Simple! Just grab an old computer power supply and rob a few parts from that!

What I did was remove four small 1 ampere Schottky rectifier diodes from the computer power supply circuit board and connect them in a full wave bridge rectifier configuration directly on the terminals of the meter. The (+) and (-) terminals of the meter are then connected directly to the (+) and (-) outputs of the bridge rectifier. The other two bridge rectifier connections, (shown as home-made ring terminals in this picture,) are the RF input connections to the bridge rectifier.

Since the meter only reads 1 mA full scale, and I wanted to be able to read 1 A full scale, I placed a non-inductive shunt resistor of 0.1 Ohms resistance directly across the meter (+) and (-) terminals to bypass the other 999 mA of current.

How this works:

The incoming RF current is rectified by the Schottky diodes and is converted to pulsating DC. 999/1000 ths of the DC passes through the meter shunt resistor, and the remaining 1/1000 of the DC passes through the meter. This causes the pointer of the meter to deflect in proportion to the applied RF current. Because the pulsating DC is at a high frequency, there is no visible "bobble" of the meter's pointer during operation.

The Shunt Resistor:

Calculating the shunt resistor value was done by first determining the internal resistance of the meter. In this case, it is 100 Ohms - which just happens to be shown on the front of the meter scale. Next, I determined the voltage that would have to be placed across the meter's resistance of 100 Ohms to cause a full scale deflection (1 mA).

so: E = I * R

or: E = .001 A * 100 Ohms

or: E = 0.1 V

So we need to have a resistor of such a value that when 1 Ampere (actually .999 A) flows through it, there will be 0.1 Volt dropped across the resistor.

Rounding off the current of 0.999 Ampere to 1 Ampere, and again using Ohms Law, we find that:

R = E / I

or: R = 0.1 V / 1 A

so: R = 0.1 Ohm

The power in Watts dissipated as heat across the shunt resistor at full scale current is:

W = I * E, where I is the current through the resistor, and E is the voltage drop across the resistor at that current.

In this case, W = 1 A * 0.1 V

so: W = 0.1 Watt, so a 1 watt resistor would give an excellent heating safety factor.

o - Note that because of the very low resistance of the shunt resistor, the resistor leads mush be short so that the lead resistance does not introduce measurement errors.

End notes:

o - Schottky diodes are required because standard diodes are not fast enough to prevent reverse conduction losses at RF frequencies.

o - This instrument introduces a fixed voltage drop of about 0.4 volts across the combination of the meter and the diodes. This voltage drop is fairly constant for current values from about 0.01 to 1.0 A.

o - Because of the low forward voltage drop of the Schottky diodes, the meter reading is accurate down to about 0.02 Amperes, as long as the circuit under test can accept a voltage drop of about 0.4 volts. Using the Schottky diodes eliminates the need to linearize the meter readings or to draw a new scale for the RF ammeter. The same scale will apply to DC, AC, and RF readings.

o - The voltage rating of the diodes is not critical, because they will never see a large reverse voltage. The DC meter and shunt resistor appear as a virtual short circuit across the DC output from the bridge rectifier.

o - If a higher full scale value is required, the shunt resistor and / or the meter movement may be adjusted as needed. It will also be necessary to use Schottky diodes that are rated for the higher current.

o- Although it is not shown in the photograph, it is a good idea to place an RF bypass capacitor directly across the meter's DC terminals. This is suggested because as the RF frequency increases, the coil of the meter movement will exhibit a rising impedance to the rectified RF pulses, and will cause a drop in the apparent meter reading at higher frequencies. I found that a value between 0.01 and 0.2 uF works well. Use a low inductance capacitor, such as a Polypropylene capacitor, or any good RF rated capacitor.

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73, Ralph W5JGV

[Home]

Experimental KW Switching Power Supply

Initial Design and Test Report - UPDATE #1 (March 21, 2004)

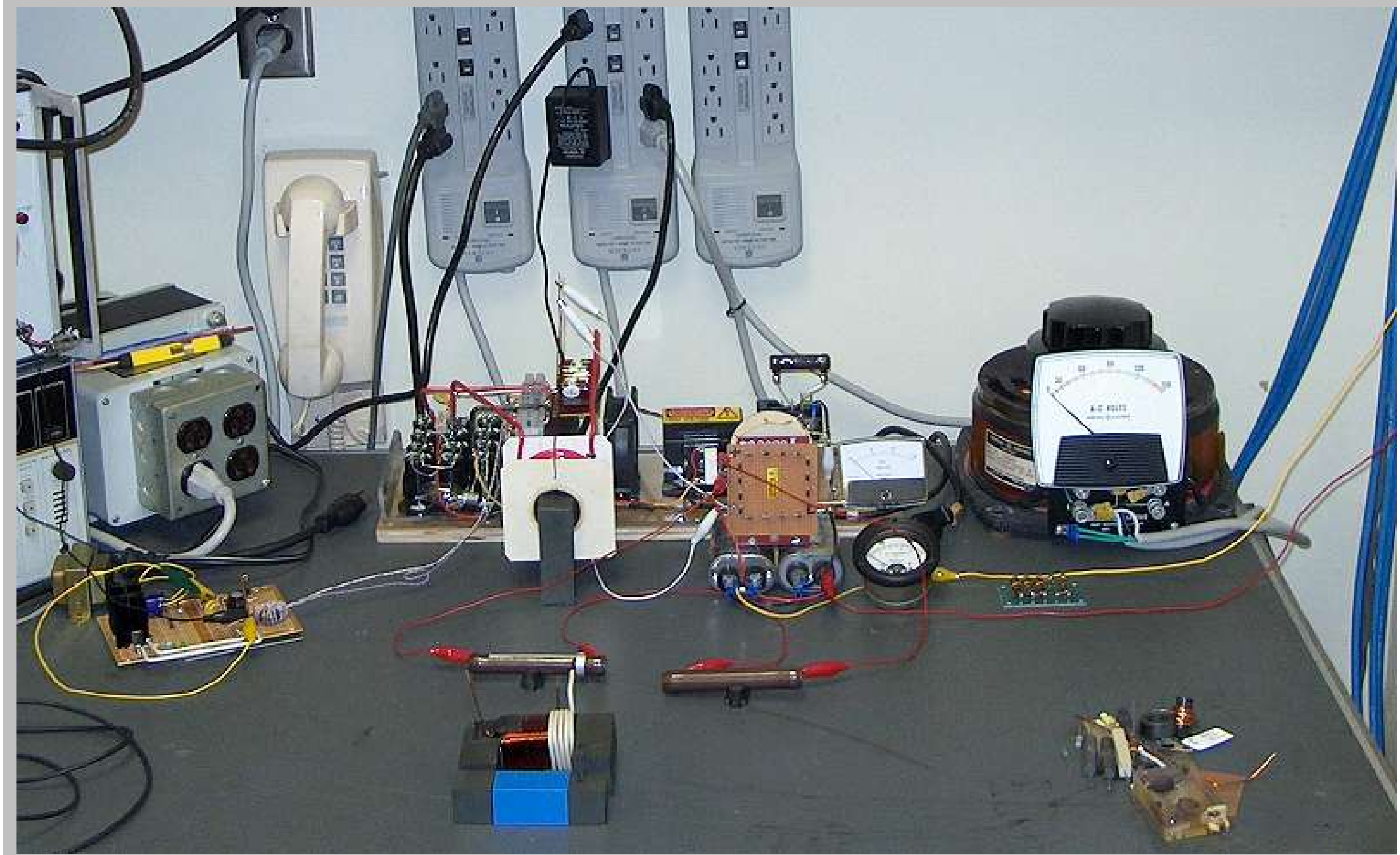
By W5JGV

Click HERE for a PDF copy of a hand-drawn schematic of the test setup.

This is an update of the ongoing narrative of my attempt to construct a high-power switching power supply to replace the failed power supply in my Heath Warrior amplifier. Since I use the amplifier for experimental (non-Ham) work, it sometimes has to operate at full CW power for several hours at a time. The original plate transformer is unsuitable for that task, so I am attempting to build a really heavy-duty supply to replace the original power supply.

My first cut at this project was to attempt to use a string of reverse-connected computer switching power supply power transformers in an attempt to get enough power from the system. I also originally wanted to use as many components salvaged from the computer power supplies as I could. This proved to be somewhat impractical, since the power I wanted to obtain turned out to be just over the edge of what I could comfortable achieve and still keep the smoke inside the components.

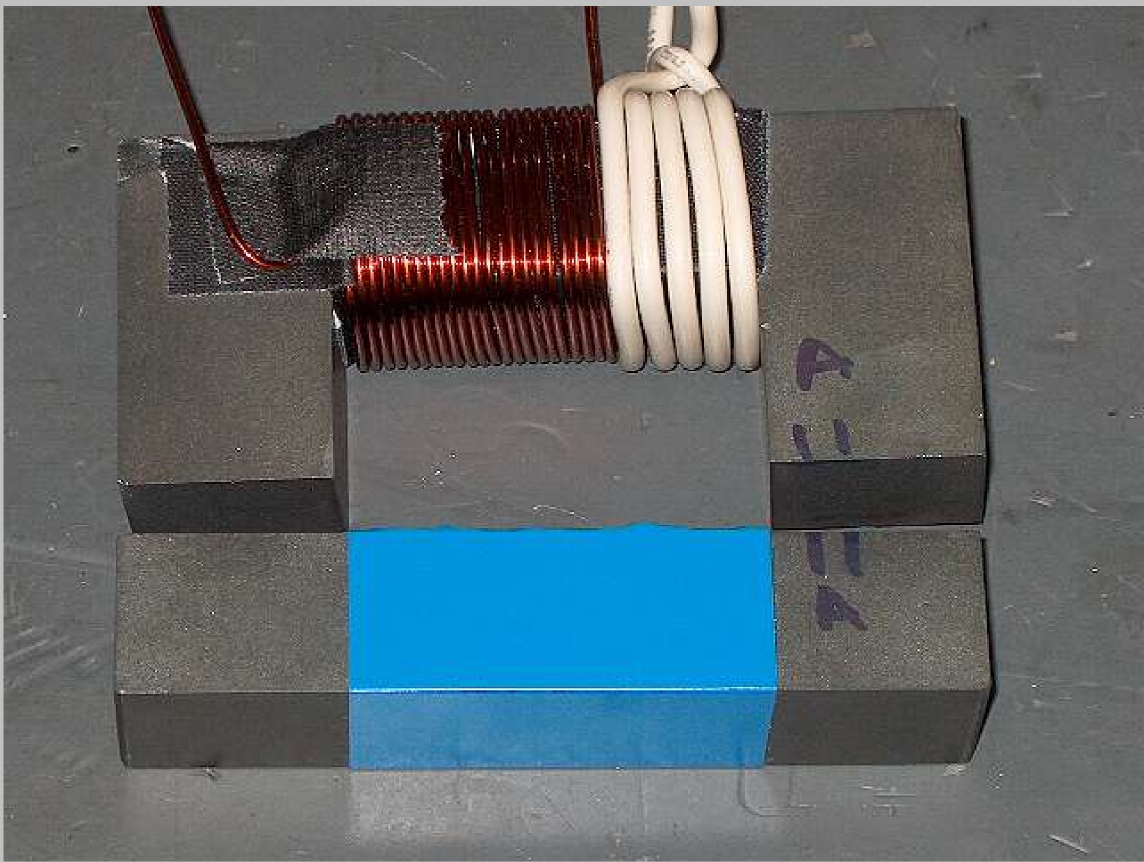
If you have read my initial episode in this project, you have a pretty good idea of what I did and how things were connected, so I won't repeat everything in detail in this update. I'll just mention what has been changed and why and what the results turned out to be.



An overview of the test bench setup, affectionately referred to as "Smoke Alley."

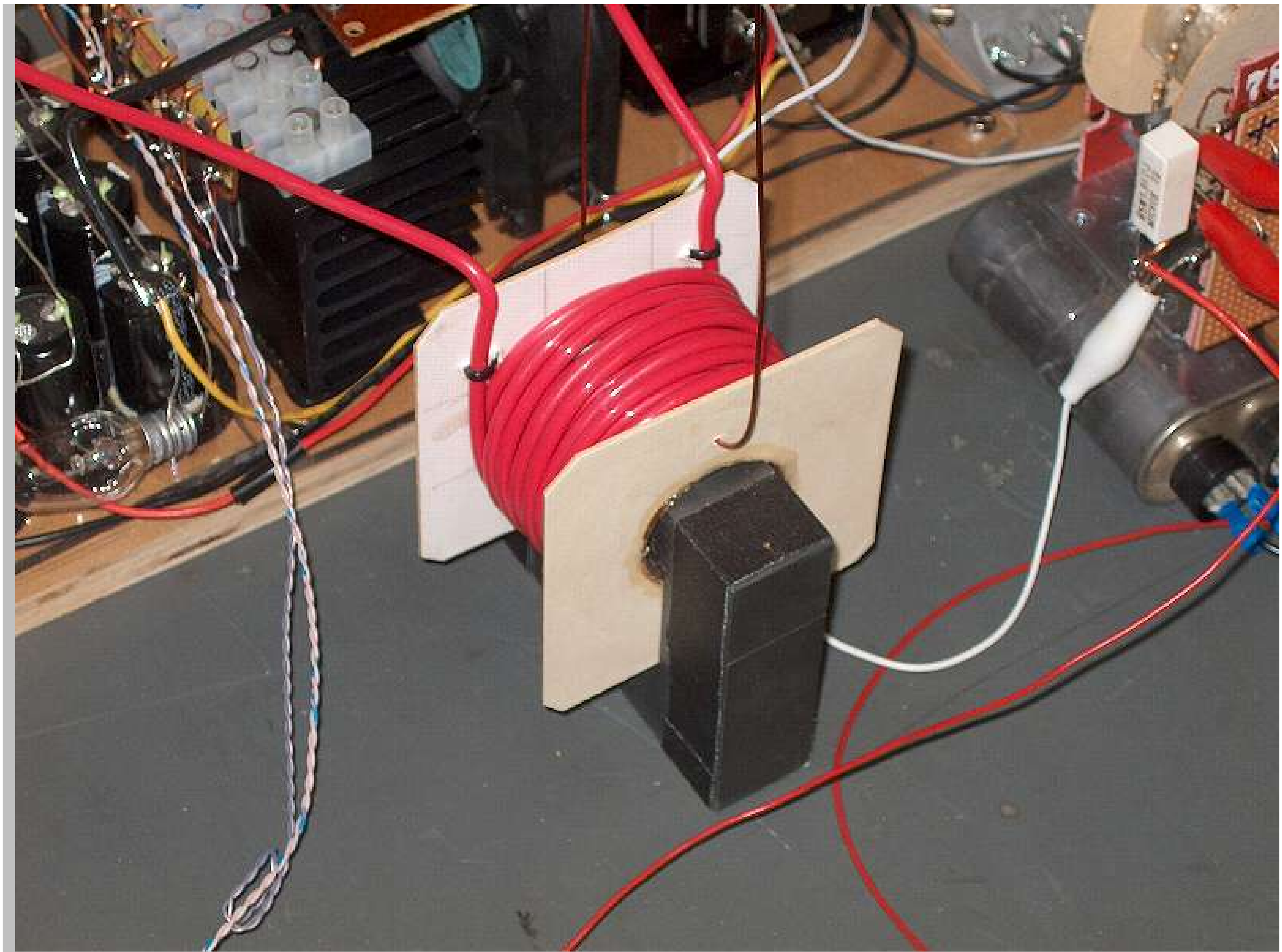
From left to right: 2.5 KVA isolation transformer (which keeps the smoke inside the operator); below the isolation transformer is the Low Voltage Power Supply and Switcher Control Board; in the middle visible below the power strips

hanging on the wall is the main switching assembly with the new switching transformer and high voltage filter choke and rectifier board. These are sitting on top of two oil-filled capacitors. The high voltage voltmeter and ammeters are to the left of the Variac (which keeps the smoke inside the components); the middle of picture shows two 1,000 Ohm 50 watt resistors which are temporarily used as damper resistors across the high voltage filter choke; in the lower middle is a test switching transformer which is wound on the same size core as the main switching transformer, and in the far lower right is a pile of junk parts I forgot to pick up before I took the picture.



High-power testing indicated that the previous two-section core I assembled from TV flyback transformers was just a little too small to be able to handle a full KW safely. I obtained several much larger cores which should work fine. These measure one square inch in cross section and have a 2" x 3" winding area. The mating surfaces are polished, and they have very low flux leakage. They appear to be made with #77 Material, and allow the transformer to operate with a turns ratio of 10 volts per turn at 40 KHz. I "backed off" from that value just a bit, and am using 7.5 volts per turn in the test transformer.

This particular transformer is one I wound for preliminary testing. I showed it here so that you could see the size of the core. The enameled wire on the core is # 16 AWG, and the white wire is # 12 THHN. The blue tape is for insulation for a test winding (now removed). I had previously scramble-wound about a hundred turns of # 26 AWG wire on the ferrite bar. At 10 volts per turn, that produced a kilovolt when I turned it on!



This is the finished (well, almost finished) switching power transformer. The coil form is a plastic pill bottle which just happened to fit the ferrite "I" bar quite snugly. The end plates are made from art board cardboard, about 1/16" thick. These are hand-fitted to the plastic tube and then super glued to the tube. Next, the form was thoroughly coated with two layers of my all-purpose plastic coating, clear PVC pipe cement. It was then allowed to dry overnight.

After drying, the secondary winding was wound on the form. It consists of 154 turns of # 18 AWG wire. The wire is larger than actually required, even after factoring in skin effect and current crowding at 40 KHz, but I had a lot of it available, and there was plenty of room on the core for it, so I used it.

To minimize winding self-capacity, after completing each winding layer I applied two layers of fiberglass tape over the winding. I then continued the winding by folding the wire back across the winding so that the next layer started from the same side of the form as the previous winding. This required extra insulation between the folded over wire and the windings to prevent insulation failure.

The primary winding in the finished transformer will be 15 turns of # 10 THHN covered wire. For my initial high power tests, I put 20 turns on the winding. I will remove the extra 5 turns after the preliminary testing is complete. The extra 5 turns on the primary winding limits the output of the system to about 1,100 Volts maximum. Removing the extra 5 turns should boost the output voltage to 1,400 Volts @ 800 MA. I will be able to voltage regulate by using pulse width modulation to reduce the voltage to about 1,300 for the the 811's in the amplifier.

Running this transformer at about 800 watts causes virtually no core heating. It should be possible to obtain about 2.5 KW from this core. The primary winding gets slightly warm at the 800 watt level due to skin effect and current crowding. The use of Litz wire for the primary winding would be a better choice than using solid wire. Another option would be to use a twisted bundle of 6 strands of # 23 AWG insulated wires as an approximate substitute for Litz wire.

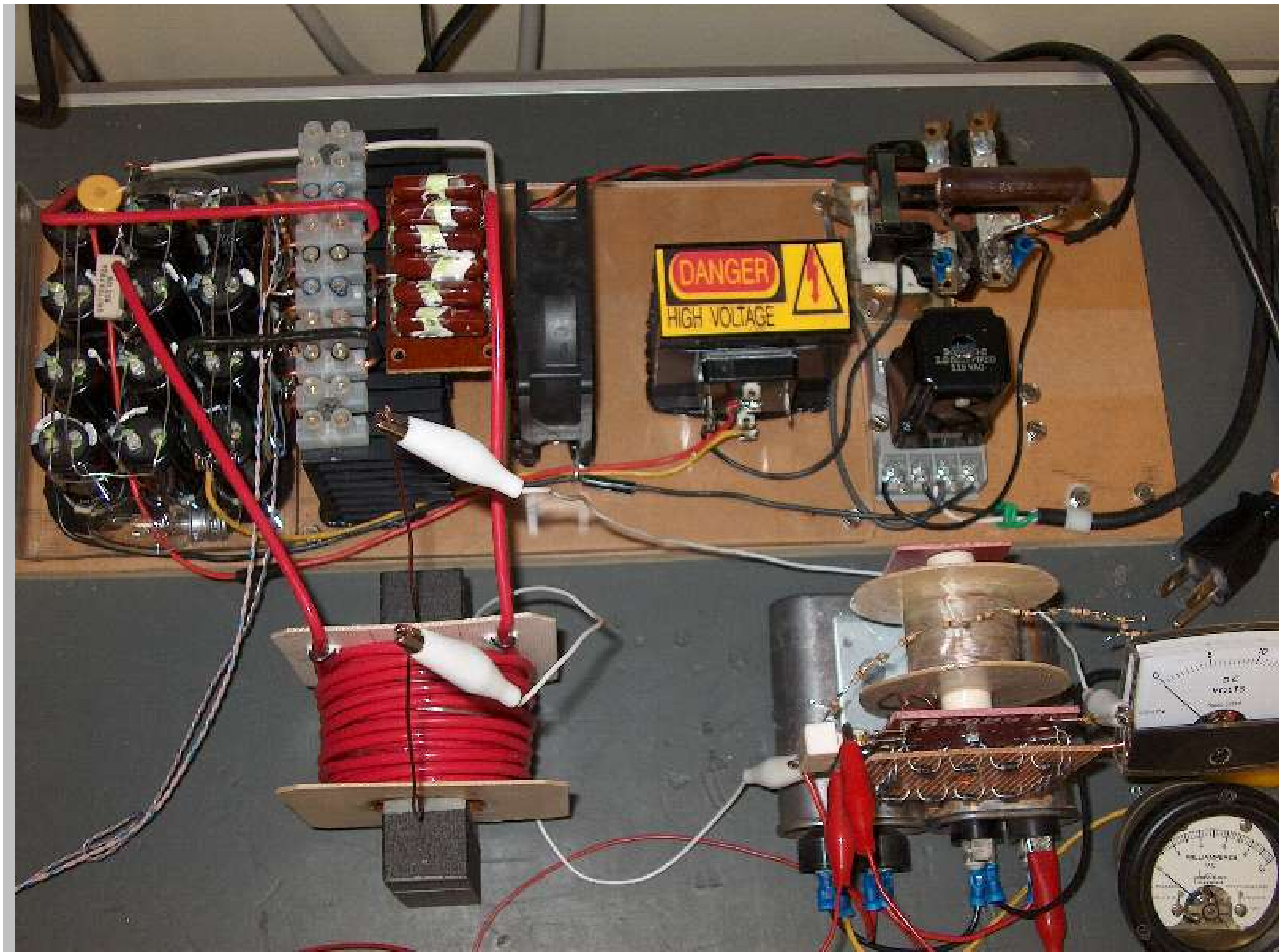
After completing the windings, the facing surfaces of the core sections were carefully cleaned and placed against each other, then bound together with Gaffer's Tape.

The primary winding of the switching transformer connects to the switcher output capacitor bank (seen here splashed with green and white paint). The other side of the capacitors (which are all in parallel and act as a single 12 uF, 400 Volt capacitor) is connected to the common point of the half-bridge transistor stack (2 transistors) which are mounted on the black heat sink under the white terminal strip. The purpose of these capacitors is to keep any direct current from flowing through the primary of the transformer in the event of an unbalanced switching waveform. Direct current through the transformer windings could cause core saturation and destruction of the power switching transistors.

The + and - 150 Volt filter capacitor assembly has been moved as close to the transistors as possible to minimize the impedance of the wiring in an attempt to eliminate switching waveform ringing and distortion. (It worked, BTW.)

A primary winding damper (snubber circuit) to counteract the effect of the leakage reactance between the primary and secondary windings is the white 50 Ohm resistor and the yellow .0022 disk capacitor visible to the upper left of the picture. These parts are connected in series and are placed directly across the primary winding of the transformer.

Theoretically, it would have been better to have wound the transformer with split primary and secondary windings, because this would have reduced the leakage inductance between the windings. This was not done because tests indicated that for this particular system, a very small reduction in transformer losses would be obtained with split windings, but the difficulty of construction would be more than doubled. In addition, it would have been almost impossible to make any changes to the windings once the transformer was wound with split windings. It was estimated that using the simple method of winding one winding over the other would result in only about 4 watts additional power loss in the snubber network.



The white clip leads connect the high voltage secondary of the switching transformer to the high voltage bridge rectifier and filter assembly which is shown to the left of the meters.

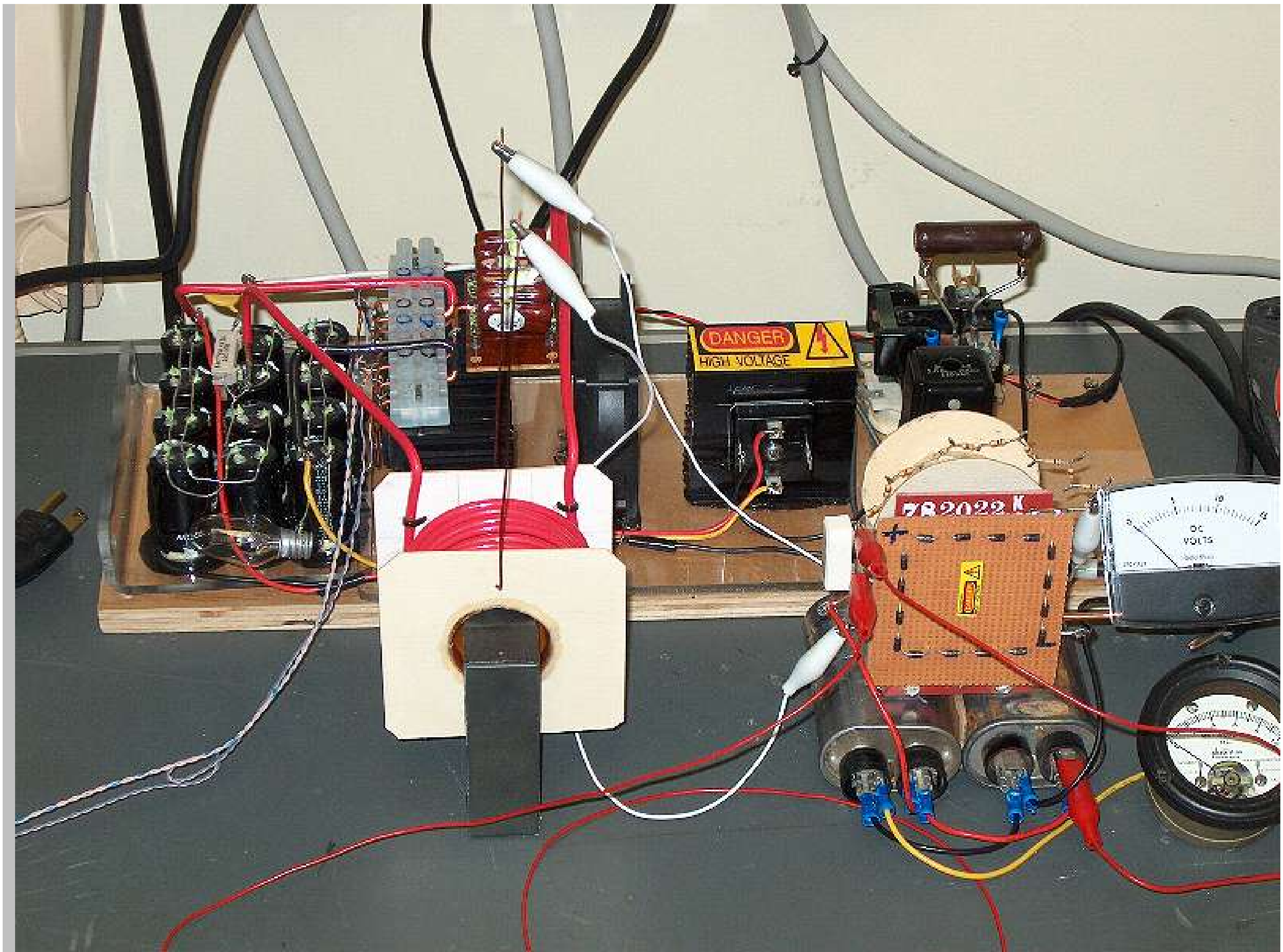
The HV rectifier is a full wave bridge made from 16 type UF4007 high-speed rectifiers. These are matched diodes, and there is no bypassing or equalization placed across any of the diodes. The diodes are mounted on the phenolic perf board which is visible just above the two HV filter caps which were salvaged from a couple of old microwave ovens. The capacitors total 2.2 uF. At 40 KC, this small amount of filtering is very adequate.

The HV filter choke is wound on the salvaged core from a TV flyback transformer. Some experimentation was required to get the right inductance and current carrying capacity without saturating the core. The number of turns and the air gap was adjusted for optimum results.

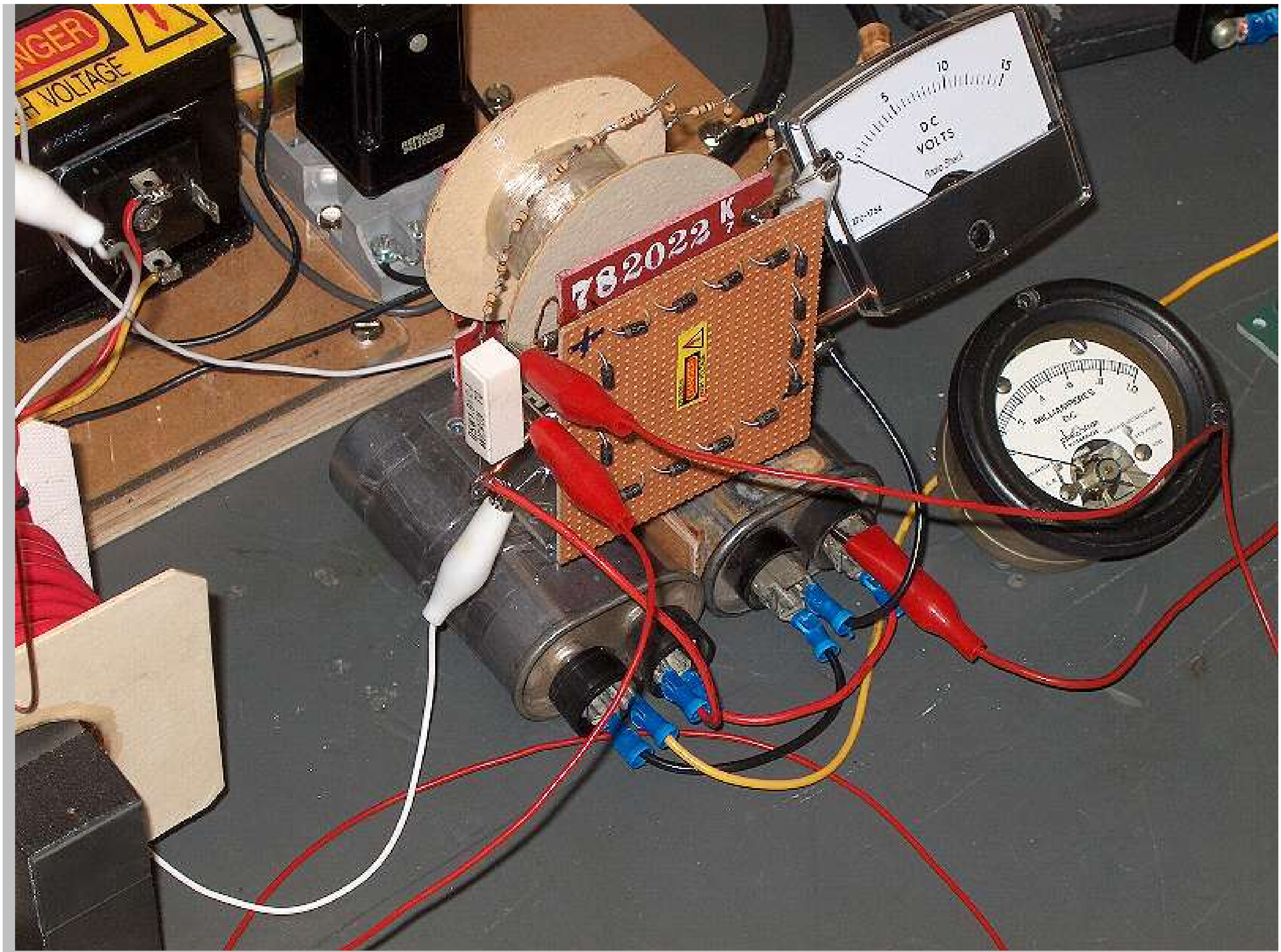
Visible just to the left of the perf board is a rectangular white power resistor. This is used as an oscillation damper load for the filter choke, which "rings" when the diodes stop conducting. The original value was 1,820 Ohms @ 5 watts. This worked perfectly well when the switched driving waveform was a 50/50 square wave, however when pulse width modulation was attempted at a 20/80 ratio, the resistor erupted in flames within 5 seconds of power on! Measurements showed that it was necessary to increase the power rating of the resistor to 100 watts.

Unfortunately, a considerable amount of power is wasted in this resistor and cannot be recovered. It will be necessary to revise the design of the filter choke to handle the increased harmonic energy generated at short switching duty cycles.

The voltmeter (whose scale reads 0-15 Volts DC), has a string of dropping resistors to scale the meter to read 0-1,500 Volts. The 0-1 MA meter has been shunted to read 0-1 Ampere. These monitor the HV DC output from the power supply.

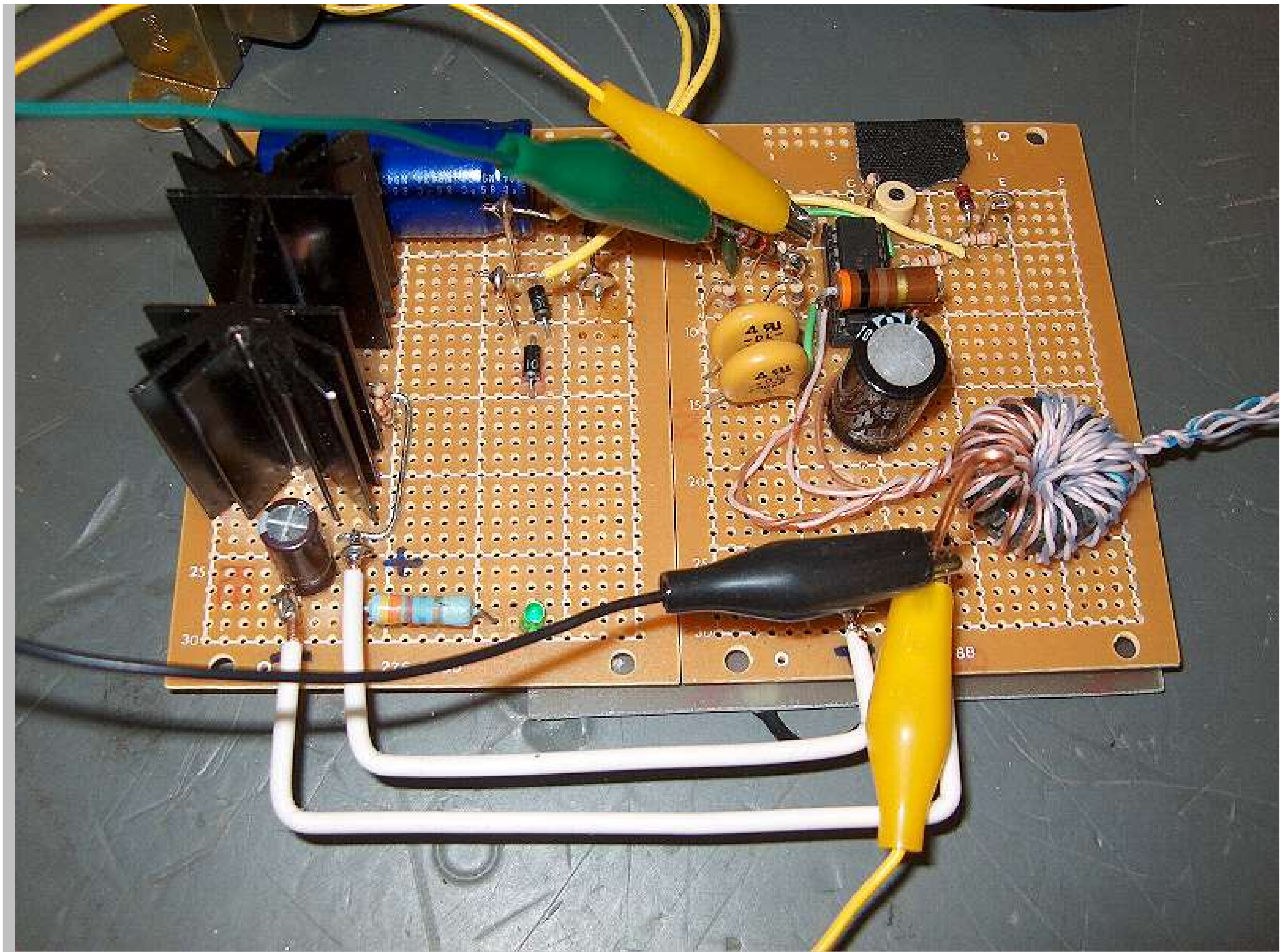


Another view showing the filter assembly and the voltmeter dropping resistor string.



A close up picture of the rectifier - filter assembly and metering. Note the red clip leads connected to the white shunt resistor (now burnt out) they connect to the temporary resistors visible in earlier photos.

Remember - this is a test bench stuff, and will be repackaged for placement in the amplifier; in the meantime, keep your fingers out of the HV!!



And the last picture - the low voltage power supply and the switching control board.

I changed the power supply from a full wave bridge rectifier circuit to a full wave rectifier and dropped the regulated voltage from 17 Volts to 10.5 Volts because that's all the control chip needed to provide enough drive to the switcher transistors.

I was not able to get enough base drive using the original bipolar transistors, so I switched to a pair of International Rectifier IRG4PC40U IGBT transistors salvaged from another computer power supply. These interesting devices have the gate drive requirements and advantages of MOSFET's, and the voltage and current ratings of a bipolar device.

The switcher control chip (TL494) drives the small toroidal gate driver transformer seen here. The primary is a bifilar winding of 10 turns (10-0-10) and the secondary is two twisted wires of 15 turns each, each of the two wires forms a separate secondary which drives one of the two switching transistors. The gates of the transistors "look" like a 0.0033 uF capacitor to the transformer, so it was necessary to insert a 22 Ohm resistor in series with the gate drive signal to eliminate transformer ringing. The resistor is inserted in the circuit at the gate lead of the transistor. The gate drive signals are fed to the gates via a twisted pair of #26 wire stripped from some CAT-5E cable. - In fact, that's what the little toroid transformer is wound with.

The switching control chip works well, and by using pulse width modulation, it allows me to adjust the voltage anywhere between 250 Volts and 1,100 Volts with the twist of a knob. The finished unit will be provided with both voltage adjustment and automatic voltage regulation to compensate for load changes. Getting that to work correctly is the next part of this project.

I'll post more info in another update when I make further progress.

73,

Ralph W5JGV

[Home]

A Tree Antenna for the 600 Meter Band

Sept 8, 2007 - By W5JGV (updated January 01, 2008)

"Why put up an antenna when they're growing all around you?"

There are two antennas in this picture and one of them is not made of metal. Can you find them both?

If you look carefully, you can just see the horizontal single wire antenna in the background in the far right side of the picture. That is my 160 meter dipole antenna, which is about 20 feet above the ground. The other antenna is the large Oak tree in the center of the picture. Near the base of the tree trunk is the coupling coil which surrounds the trunk.

Yes, the tree IS the antenna!

My interest in tree antennas goes back many years, when I first read about some experiments using coils to couple RF energy to trees. Unfortunately, I neglected to save the article, and it was only much later that I was able to locate the source for the article.

Here are four articles that explain tree antennas - George O Squire Tree Antenna Patent.pdf - 1975 January Ikrath IEEE tree antennas.pdf - Robert Hand article.pdf and Signal Propagation at 400 kHz Using an Oak Tree with a HEMAC as an Antenna AD735330.pdf

It appears that there are two methods generally used to connect to a tree for using it as an antenna. The first is to drive a nail into the tree some distance up from the ground, and the second is to use a coupling coil around the trunk close to the ground. Since I prefer not to climb trees unless I really have to, I decided that the coupling coil would be the better approach.

Since little, if any, design data has been published on tree antenna coupling coils, I took a guess at what might work for the coil dimensions. I guesstimated that using a coil with about half the diameter of the tree trunk would be about right for the coil diameter. The length of the coil would be the diameter of the tree trunk. The number of turns was an unknown, but I figured that if the inductance was too small the tuning would be very sharp, and changing environmental conditions, rain, temperature, etc., might cause tuning problems. A larger inductance would be less sensitive to such things.

I decided on an inductance of about 175 uH as a starting point. That would require a coil of about 75 turns of about 10 inch diameter, or a total of about 195 feet of wire. Since I had a lot of #10 AWG bare copper wire available, that was used for the construction of the coupling coil.

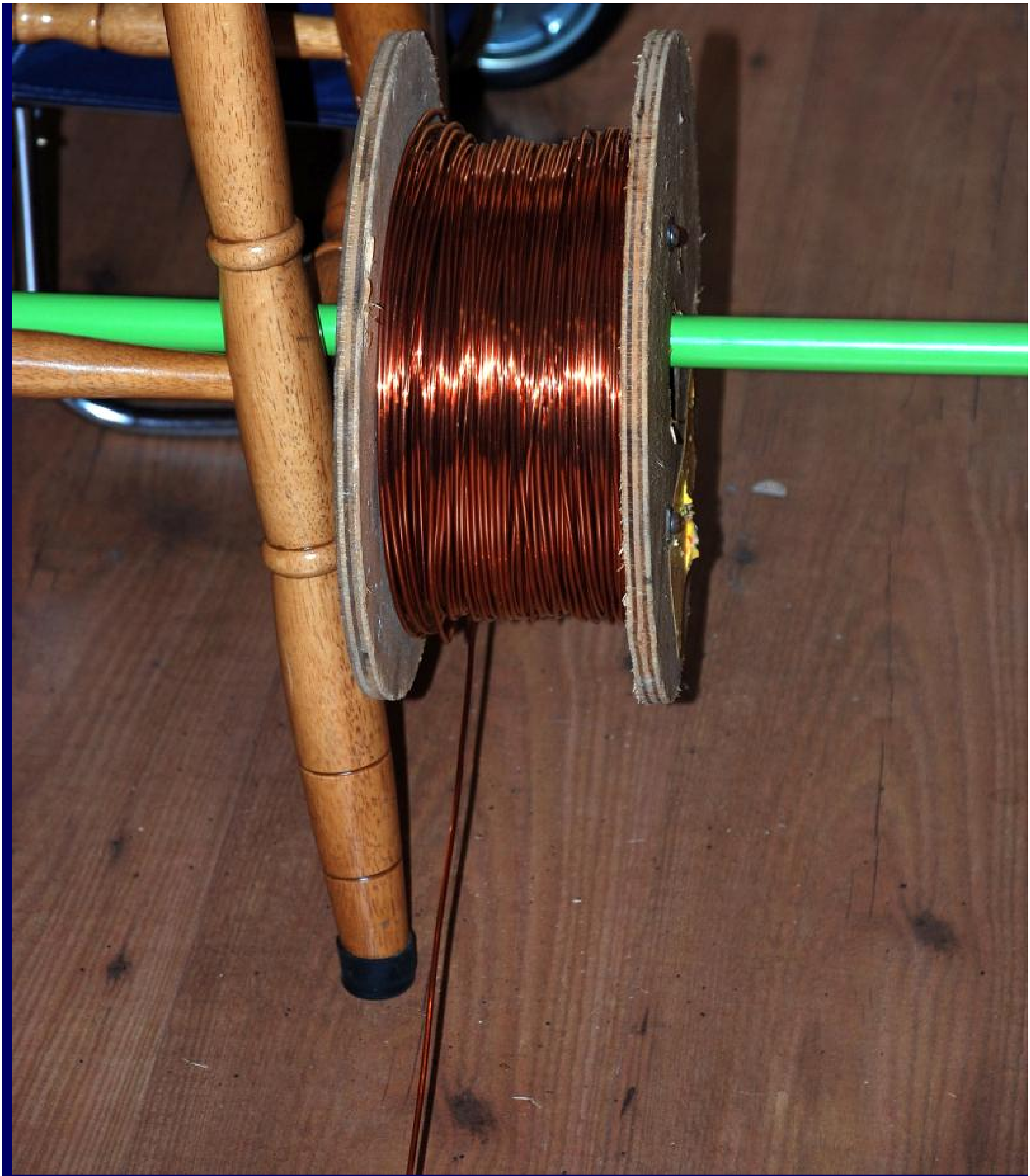
Tuning the coil to resonance at 505 KHz would require approximately 575 pF of capacitance. At resonance, the coil losses would be about 10 Ohms, which would not be too good for transmitting, but for receiving, it should not pose a problem. At resonance, the impedance of the circuit would be about 30 Kohms so it would be a fairly good match for FET RF preamplifier.

Designing the coil was one thing, but how was I going to hold it in place against the tree? It had to be held away from the bark, or losses would increase when the tree got wet in the rain. After wearing out several pencils and using up the back of a lot of old envelopes, I finally hit on the idea of dropping each turn of the coil into a series of parallel slots cut into a length of plastic pipe. Then, when I bent the pipe around the tree, the flexing of the pipe would cause the slots to close up slightly and squeeze the wire tightly between the sides of each slot. At

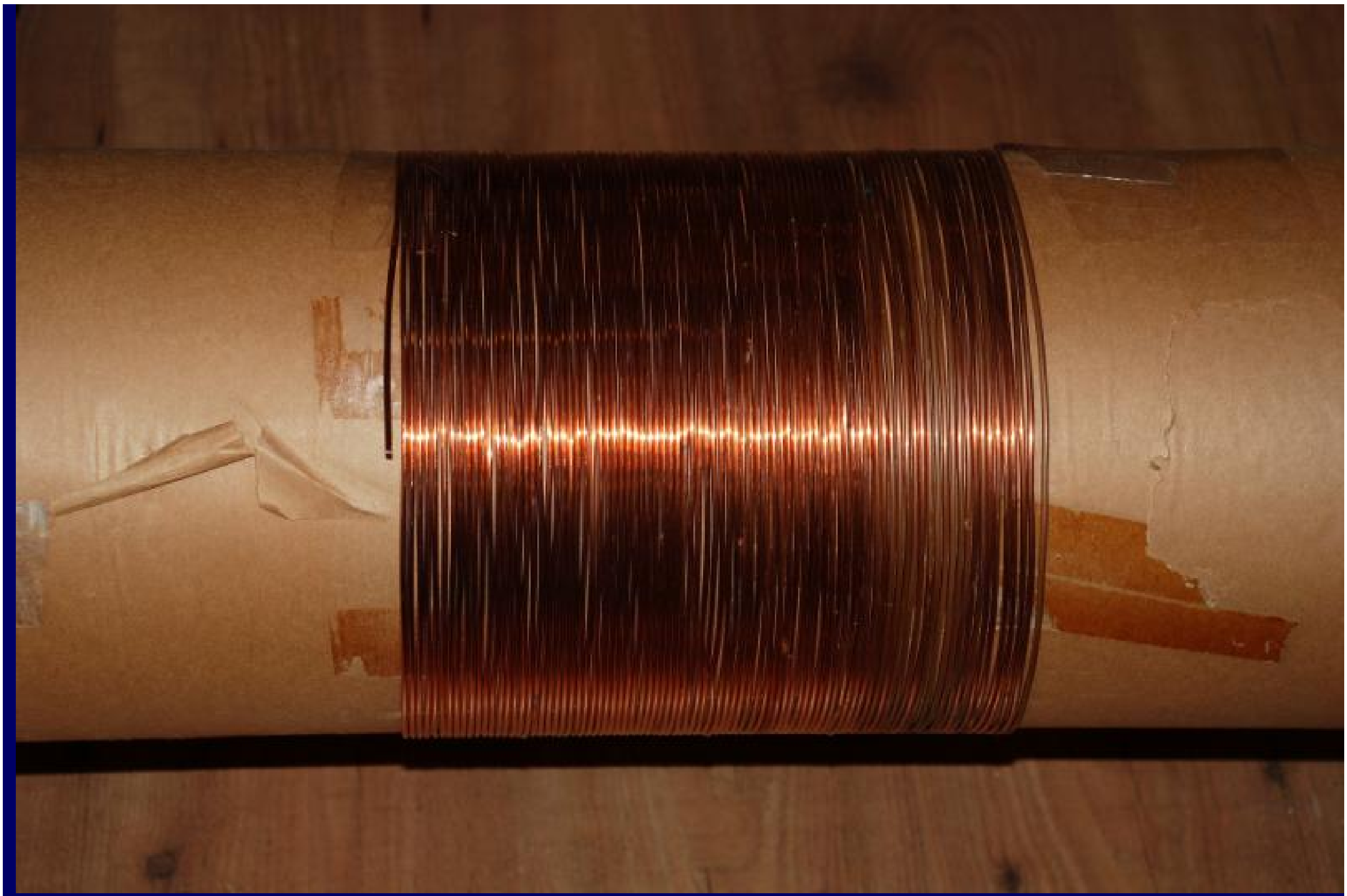
that point, all I'd have to do was to manhandle seven feet of flexible pipe and a hundred loose turns of copper wire into place while screwing the whole thing firmly to the tree trunk. I figured I'd work on that little problem after the coil was built.

Time to start construction!

Construction of the coupling coil was started by running a broomstick through a roll of Bonnie, KB5YSE's art studio wrapping paper and supporting the roll between two wooden chairs. The roll measures about 9 inches in diameter, and made a solid form on which to wind the #10 AWG bare copper wire for the coil. The free end of the wire was simply taped to the roll of paper and winding was begun. After about 90 turns were wound on the form, the coil was carefully removed from the form and set aside for later installation.



The wire I used was left over from a commercial AM broadcast antenna installation I did many years ago. It is bare, soft drawn, #10 AWG pure copper wire. It was just right for a coil of this size, since it is strong enough to hold its shape without any extra support.



Here is the finished winding while it is still on the winding form. It looks neat at this point, but as soon as I loosened the wire to remove it from the form, it promptly sprang into action and unwound into a larger diameter shape, and instantly piled up into what appeared to be a massively tangled heap! Fortunately, it was very easy to unravel, and placement of the wire coil onto the supporting tube went along without any unexpected difficulty.

All that wire has to be supported somehow, and I figured the easiest and cheapest way would be to take a length of 1" diameter plastic pipe and cut an evenly spaced series of slots into the pipe. As the pipe was bent around the tree and fastened in place against the tree, the slots would close up slightly as the pipe was bent. This would "put the squeeze" on the wire and hold the coil firmly in place. I drew a series of pencil marks spaced one inch apart on the pipe. The slots were then cut a little more than halfway through the pipe using a carbide tipped saw blade on a table saw. I made a "sled" for the saw to hold the pipe tightly in position as I cut the slots. The use of the sled also kept my fingers well away from the saw blade during the cutting process.

Well, here's the coil in place around the trunk of the tree. I'd like to say that the uneven placement of the ends of the tube were to ensure proper drainage of water from the tube when it rains, but in reality, I just screwed up a bit and didn't line things up quite right. (Hmm... I think I like the rain drain idea better!)

Seen from the other side of the tree, the coupling coil looks a bit better. The black screws that hold the pipe against the tree are not tightened up snugly. You must allow some slack here, or as the tree grows it will crush the pipe and eventually pull the screws right through the pipe, ruining the coil.

In this top view of the support pipe, you can see how the slots close up as the pipe is bent around the tree. As the slots close up, they pinch the turns of the coupling coil tightly. After the pipe is fastened in place, you cannot pull any of the turns through the slots. It's tight! The difficult part is that each turn of wire must be hand adjusted as the turns are placed into the slots. Of course, while I was doing this, about six other turns were trying to jump out of their slots. It turned out to be a real "juggling act" to get the turns to stay in place as I assembled the coil, but I finally beat the recalcitrant coils into their proper positions; order prevailed, and I got the coil finished at last.

Tune up time! Does it actually work?

A quick test setup was made using a portable radio and an old 435 pF dual section variable capacitor salvaged from a defunct broadcast receiver. The coil resonated with the calculated amount of capacity connected across it. As it eventually turned out, this was about the easiest way to tune the antenna. All I have to do is to position the portable radio antenna close but not touching the coupling coil. The radio is then tuned to the frequency at which I want to tune the antenna. When the coupling coil is tuned to resonance, the signal (or background noise) in the radio increases, indicating that the system is tuned to resonance at that frequency.

After the first tune up was so successful, I quickly constructed the elaborate weather cover you see here. Slits were cut into the bottom of an empty plastic water bottle and the tuning capacitor and feedline connections were stuffed into the bottle. This setup, complete with the Radio Shack clip leads, was used for several days before a more permanent enclosure was installed.

Now, this looks more like it! The enclosure is one that I salvaged from my Katrina-ravaged tower at my old QTH in New Orleans. The cabinet is at least 30 years old (Hoffman makes good stuff, you bet'cha!) and has been out in the sun and rain all those years. It is still weather tight using the original gaskets. It is Fiberglass and was starting to shed glass strands, so I refinished the outside of the enclosure.

There are two connections visible on the left side of the enclosure. The connection closest to the tree goes to the left ("cold") end of the coupling coil. This end of the coil is also connected to ground. The front-most connection goes to a tap on the coil that is 10 turns from the ground end of the coil. This is the feed point for the 75 Ohm coaxial cable that goes to the receiver in the shack.

A close-up view of the tap and cold end of the coil connections.

Stainless steel through bolts carry the signals through the Fiberglass walls of the enclosure. Sealer is applied to the bolts so that rain will not enter the enclosure. The bolts that hold the enclosure against the tree are not snugged up tight, there is room for the tree to grow. Both the bolts holding the enclosure to the tree and the screws holding the coupling coil in place will have to be backed out slightly every year or so.

The ground system for the coupler uses three steel screws that are driven into the roots of the tree. I figured that the tree probably has a better connection to the ground than I could manage to get by driving a ground rod. After running the screws into the roots, the screws are removed and the end of an aluminum wire are pushed down into the holes. The screws are then replaced. This gives a good connection to the damp wood. Do NOT drive copper or brass wire or screws into a live tree, as the copper may kill the tree. Iron, steel or aluminum is OK.

At the center ground-root, the wires from the other two ground-roots and the twisted pair of ground wires from the coupler circuit all come together. All the wires go about two and a half inches into the tree root. I used aluminum electric fence wire for the ground wires.

The ground wire goes from the tree roots to the coaxial connector on the bottom of the tuner enclosure.

A split-bolt wire connector connects the ground wire to the pigtail coming from the connector.

As you can see, the enclosure is mostly empty space. A much smaller cabinet could be used, but this one was available and didn't cost me anything

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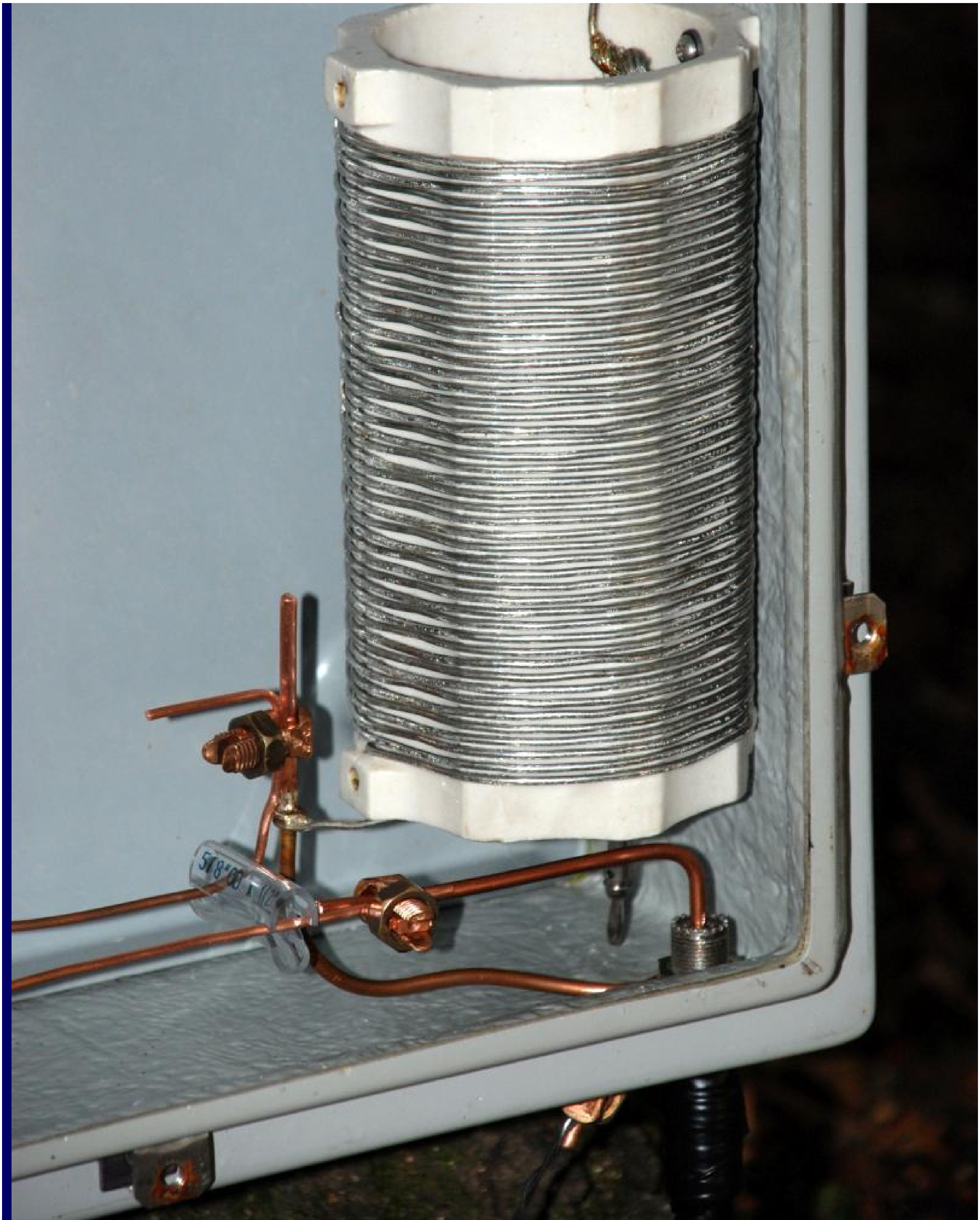
The frame of the tuning capacitor is simply bolted to an aluminum angle bracket and fastened directly to the grounded through bolt. Since the capacitor frame is grounded, I cam simply grab the dial cord drum on the end of the capacitor shaft and turn it as needed to adjust the capacitor.

Both sections of the capacitor are in parallel, and connected to the wire leading off to the right of the picture. That wire goes through a ceramic feedthrough insulator on the right side of the enclosure and then connects to the hot side of the coupling coil.

The wire closest to the back of the cabinet is the ground wire between the cold end of the coupling coil and earth ground. The wire nearest the front of the cabinet connects the coil tap to the center wire of the coaxial cable going back to the shack. Two spacers made from vinyl plastic tube that were used to hold the parallel wires in place.



I had previously installed this 100 uH coil in the enclosure to be used as part of a shunt feed tuned for my old tower on 75 Meters.

However, even after much tinkering, it never worked properly, so I abandoned that project. It was only after removing the coil to refinish the enclosure for this tree antenna project that I realized that the cause of the problem was. It seems that when I wound the coil, I covered the winding with what apparently was a VERY good clear varnish, because it prevented the E. F. Johnson squeeze clips that I used from making contact with the wire! No wonder it would not work!! All I can figure out is that I must have had total brain fade when I built the tuner. I left the coil in the enclosure, since it just looks so nice. <G>

Except for the RF preamplifier, this is the finished system. I simply ran the coax cable over the ground and back to the shack. It's easy to change if I need to, and the lawn mower misses it. In a year or so, the grass will have grown over it and it won't be noticeable.

While working on the tuner, I noticed this little guy walking across the turns of the coupler coil. If he had been parallel to the turns, I probably would never have noticed him.

CLOSING THOUGHTS -

- The tree I chose for this project is about 90 feet tall. There are others available that are taller, or more in the clear, or both, but this one was in a good spot for testing. It is far enough from the house so as not to pick up

much "house noise" but close enough so that I can get a long extension cord out to it to run test gear. I may try a different tree at some point.

- I suggest using aluminum electric fence wire or aluminum clothes-line wire for making the coil. That would make the coil lighter and easier to handle during construction, and the losses in the coil will not be enough greater to worry about. One advantage of the #10 bare copper wire is that it fits perfectly in the slot cut by the circular saw blade. Other types of wire may require a different width slot and considerably more construction effort.

- I strongly suggest that you drill the holes for the mounting screws through the plastic support pipe BEFORE you try to attach the coil to the tree, unless you have at least six hands to hold everything.

- Having an extra person available when you attach the coil to the tree is a great help. I did it all by myself, but I waited until the dark of the moon, on a Tuesday, and I held my tongue >just< so. ;)

- I did not use any isolation transformers between the coupling unit and the coax feedline going back to the ham shack. I did not see any extra noise pickup from the coax cable either with or without the cable grounded at the tree end of the cable. Your installation may be different, of course. I happen to have (finally!) a very low RF noise QTH.

- This coupling coil was designed for MF operation. The tuning range of the coil with the capacitor I used is from roughly 428 KHz to 1150 KHz. No detuning of the system is noticed unless you bring your hand within a few inches of the hot end of the coil. A coil with fewer turns would probably work better for HF work.

- The signal pickup of the tree antenna seems about equal to or a little less than using one side of my 160 meter dipole antenna, which is about 20 feet high. It does seem to pick up a little less noise than the dipole, so the S/N ratio appears better overall. I have not had the tree-tenna in use long enough to make any accurate conclusions.

- I have not noticed any difference in signal pickup from day to night, nor does rain seem to change the antenna characteristics.

- Tuning of the antenna may be done by using the variable capacitor or by shorting out one or more turns of the coil on the "cold" end. This raises the operating frequency but does not seem to change the sensitivity of the antenna appreciably. Since the "cold" end of the coil is grounded, a simple relay arrangement may be used to short out some of the coil turns to ground to make frequency shifts remotely.

- The antenna works even better since I installed my RF preamplifier.

73,

Ralph - W5JGV - WD2XSH/7

[BACK]

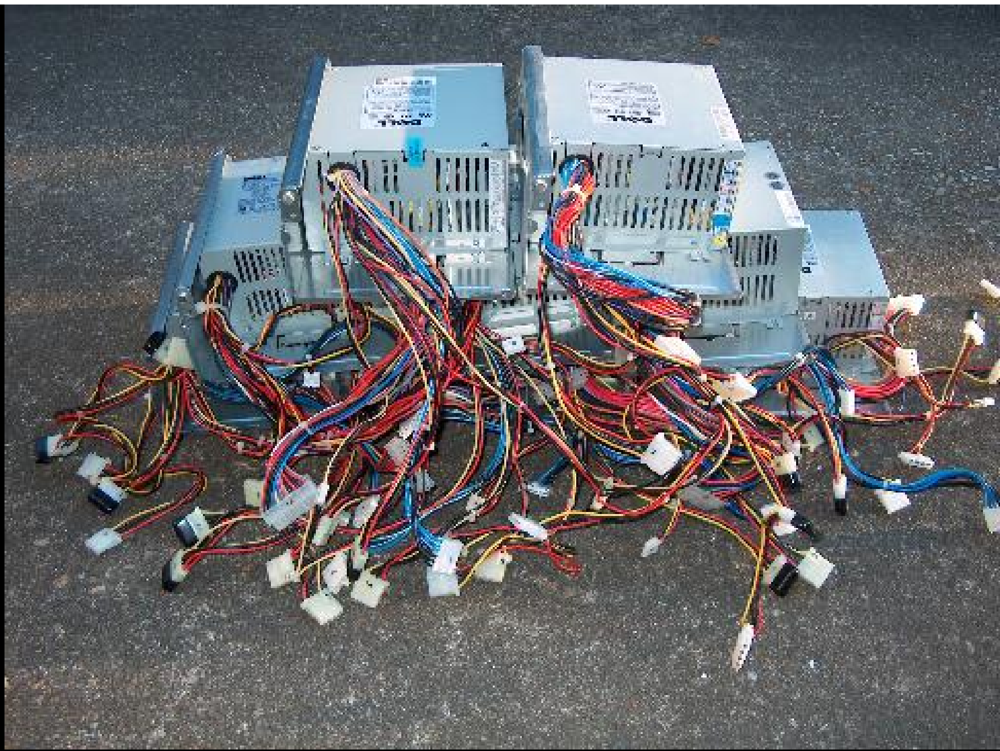
30 Volt Computer Power Supply Stack

Or: What do you do with a bunch of old computer power supplies?

This site was last updated on July 22, 2004

Wow! What a pile of power! Let's see what we can do with these gems!

These surplus Dell power supplies were chosen for a very good reason - I got them for free, and I got a LOT of them. A bonus was that I discovered that these did not need a standby load connected to the supply to keep them running - just apply mains power and close the Start lead to ground.

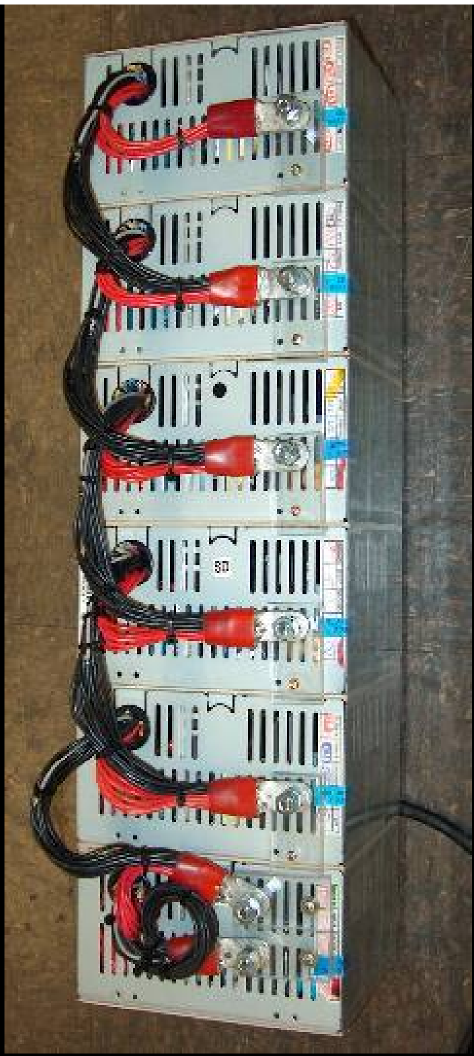


Oh Wow! Whatta' mess!! Can we ever figure this out? You bet'cha!

The nameplate says we can get 29 amps @ 5 volts - with no load on the other lines, these babies tested out at 40 amps!

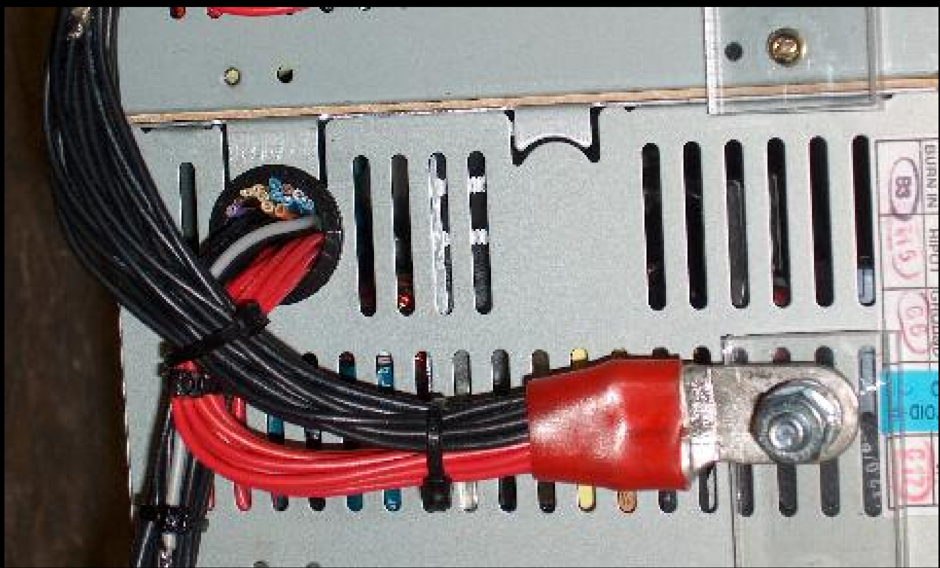
Here's the assembled Tower of Power. Six supplies in series make 30 volts at 35 amps - that's a total of 1050 watts! Taps are available every 5 volts from 5 to 30 volts.

This side view shows that there is a piece of cardboard separating the cases of each power supple so they do not short circuit each other. The supplies are strapped together with clear packing tape. The side vent holes are covered, but the holes on the ends are left open to allow cooling air to flow through the supplies.

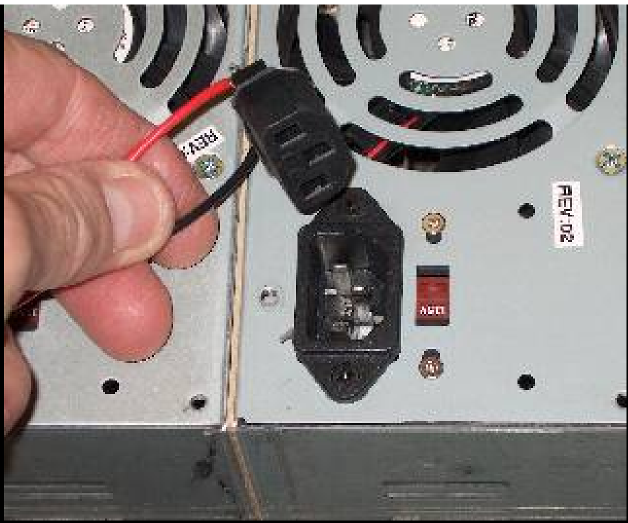


The business end of the power supplies. Note that all of the red and all of the black wires have been connected together to form a (+) and (-) cable from each supply. you can see that the black (-) lead of the bottom supply is free. It is the negative end of the Tower of Power. It is also connected to the case of the bottom supply. The case of the bottom supply is also connected to earth ground through the power cord. note that none of the other supplies have their cases grounded as they are all above ground potential.

This shows the plastic insulators I made to hold the tap point terminals between each power supply and it's neighbor.

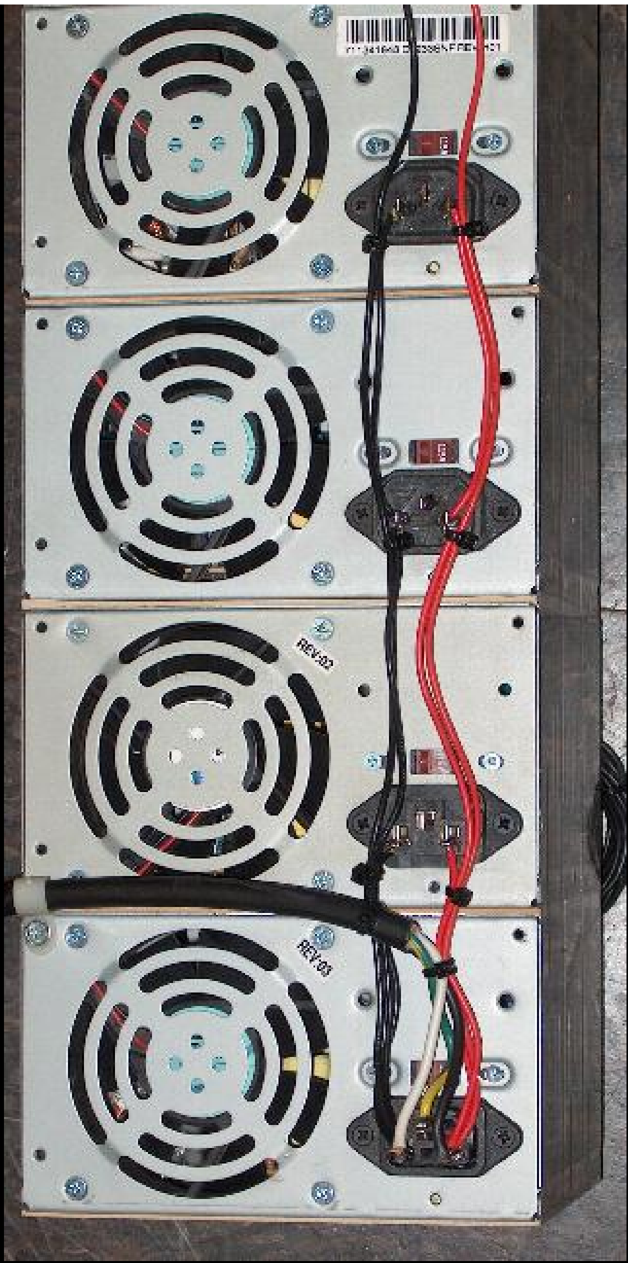


A close up of one of the tap points. Note also that all the other wires from the supply have been cut off as they exit the case of the supply. The gray wire is the power supply start line. It is connected to one of the black ground leads from that supply. That starts the supply running as soon as the mains power is applied to the supply.



The mains connector going to the top supply. Note that it has only the mains wires connected to it. The ground lead is not connected.

An overall view of the Tower of Power mains wiring. The power cord goes to the bottom supply which has its case grounded to earth through the power cord. A separate set of power wires splits off of the first mains connector and feeds two supplies. That reduces the mains voltage drop between the supplies under load and ensures that all the supplies get the same mains voltage.

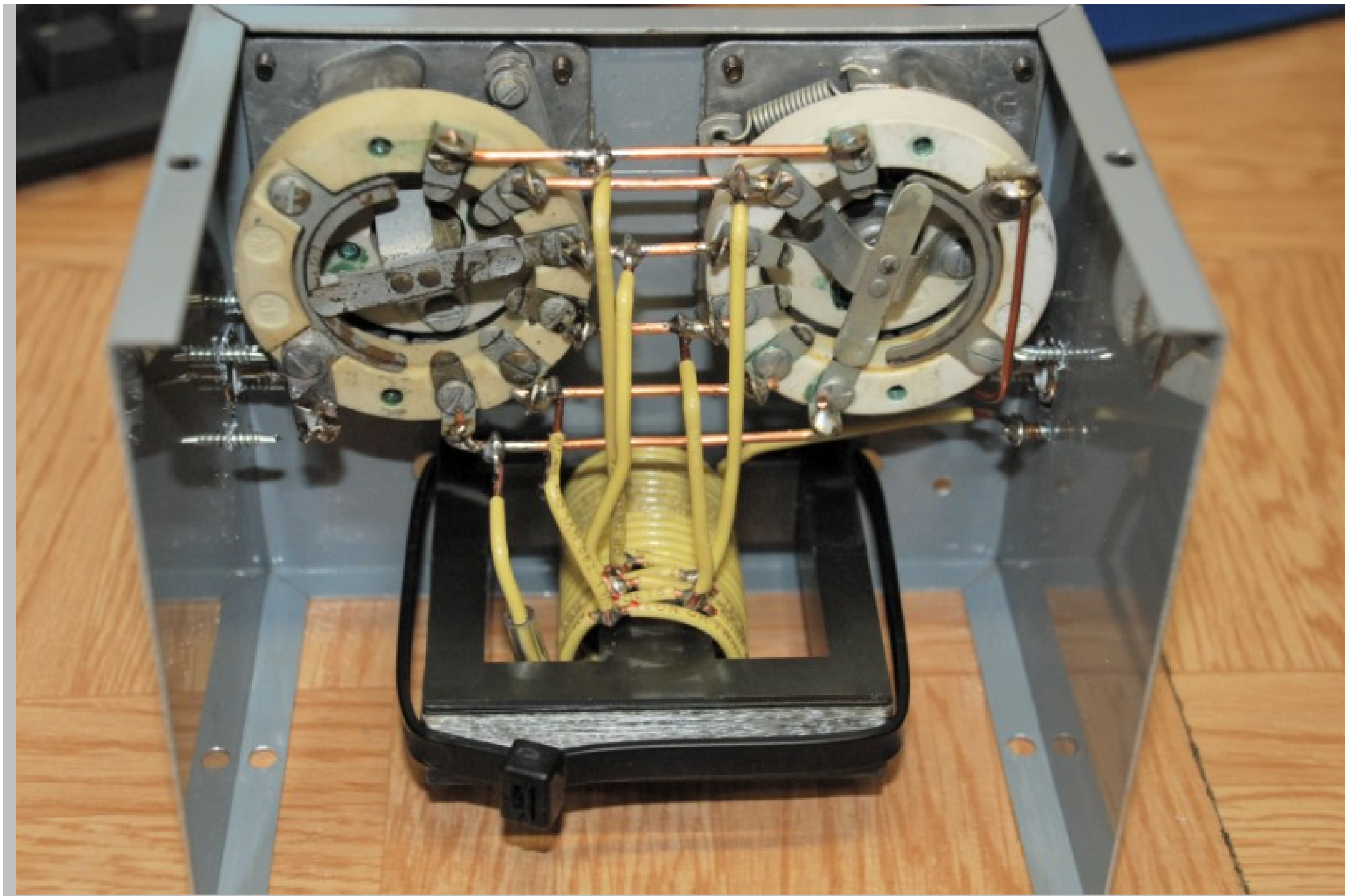


A closer view of the mains power distribution system.

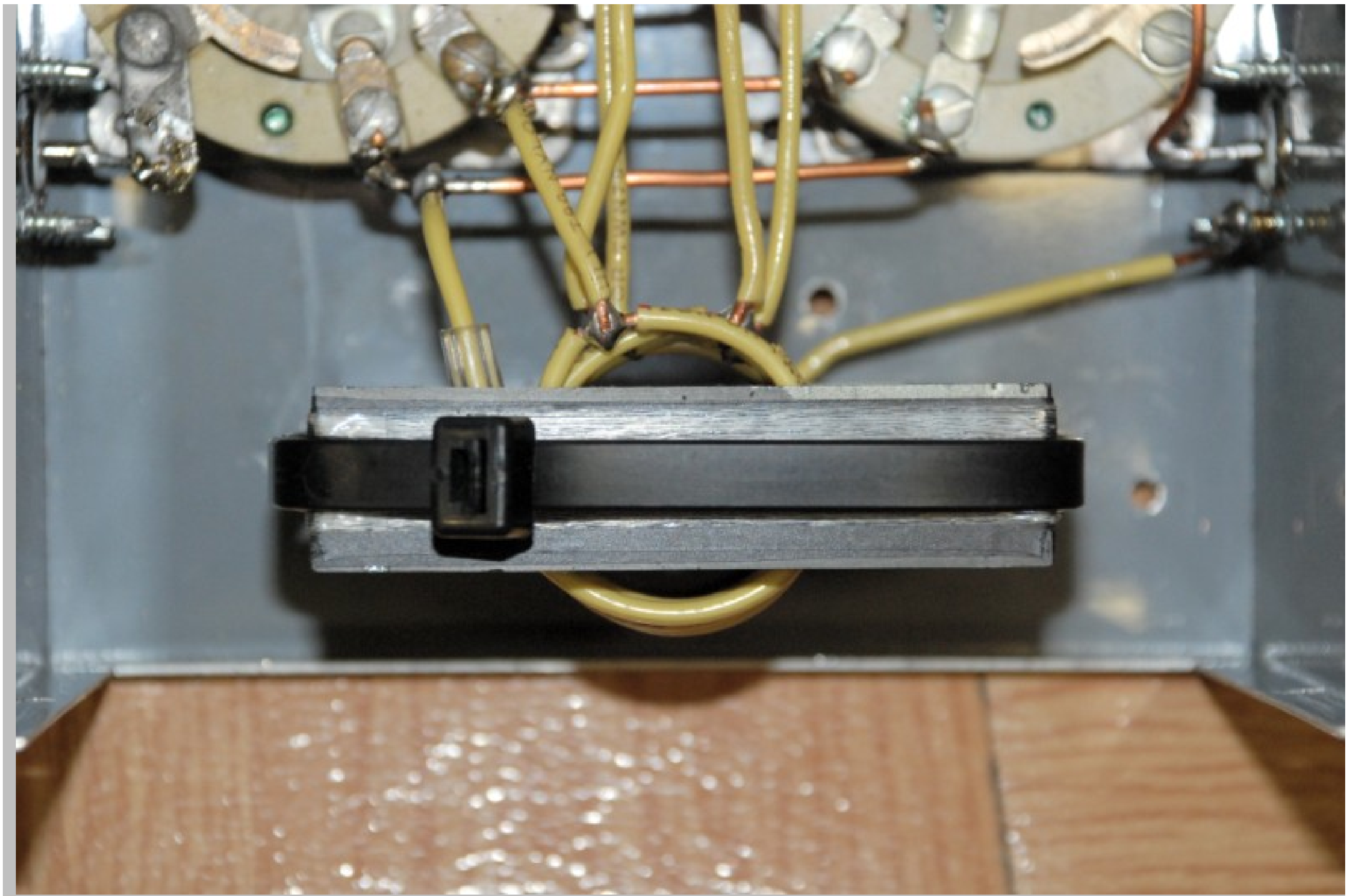
[Home]

Using half of a Bud Box, the transformer is held in place by a large plastic Tie Wrap fastener. The left switch is for the input from the transmitter, and the right switch is for the output to the antenna.

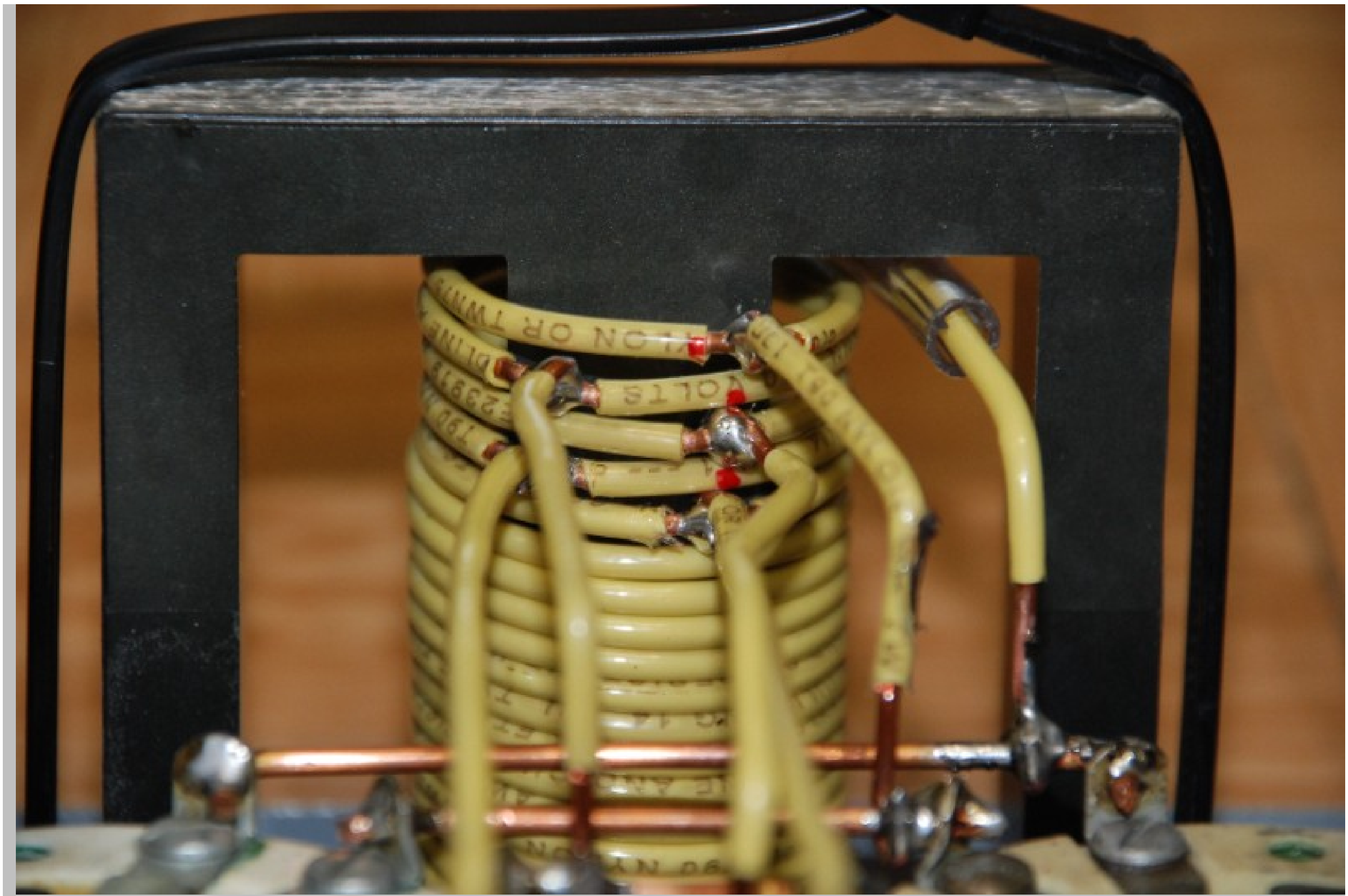
Switch position 1 is connected to the top of the transformer winding, and position 6 is 5 turns further down on the winding.



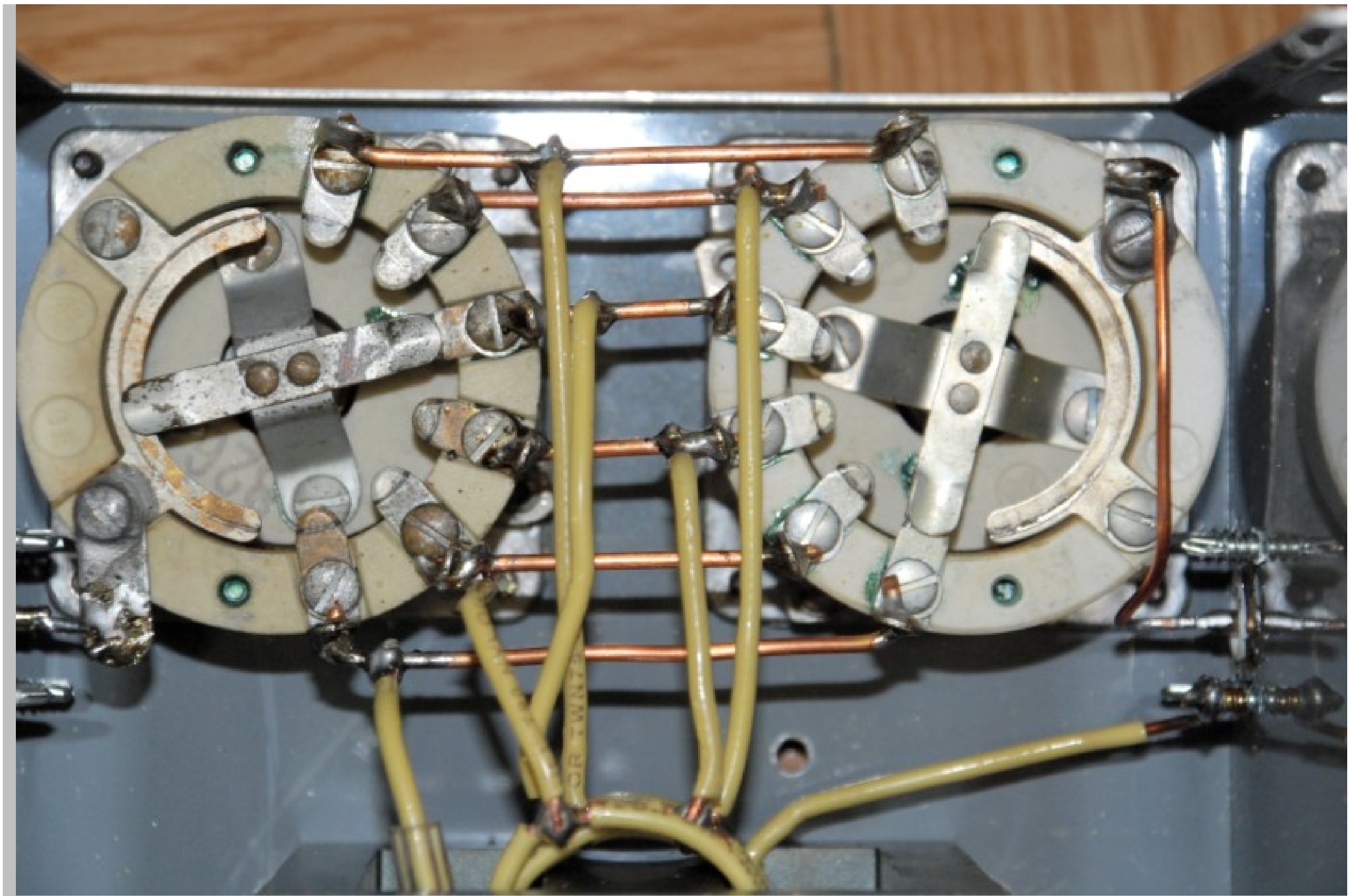
An overall view of the switch and transformer assembly. Layout was done to minimize connecting wire length to avoid excessive RF losses at high power.



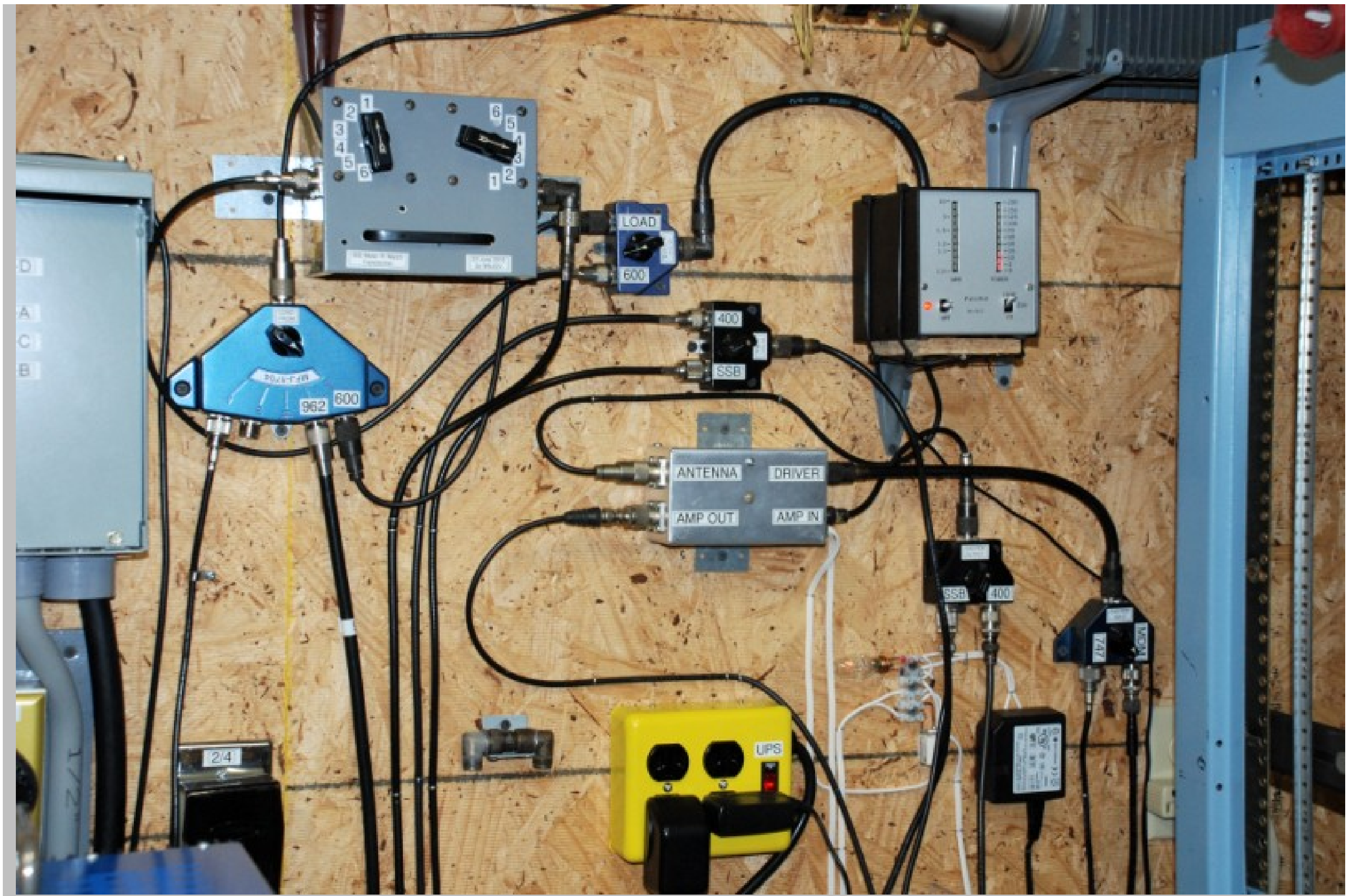
A top view of the transformer. No coil form is used; the winding supports itself. This allows for better cooling air flow around the coil and the transformer core.



The taps on the transformer winding were easy to make. I wound the first six turns of the coil, then made a pair of lines slightly offset from each other end-to-end on the coil. Then I unwound the coil and carefully removed the insulation where the marks were placed, being sure to the alternate gaps in the insulation from one set of lines to the other. That way the taps do not short to each other. Next I soldered the tap wires to the places where I had removed the insulation, and then rewound the coil.



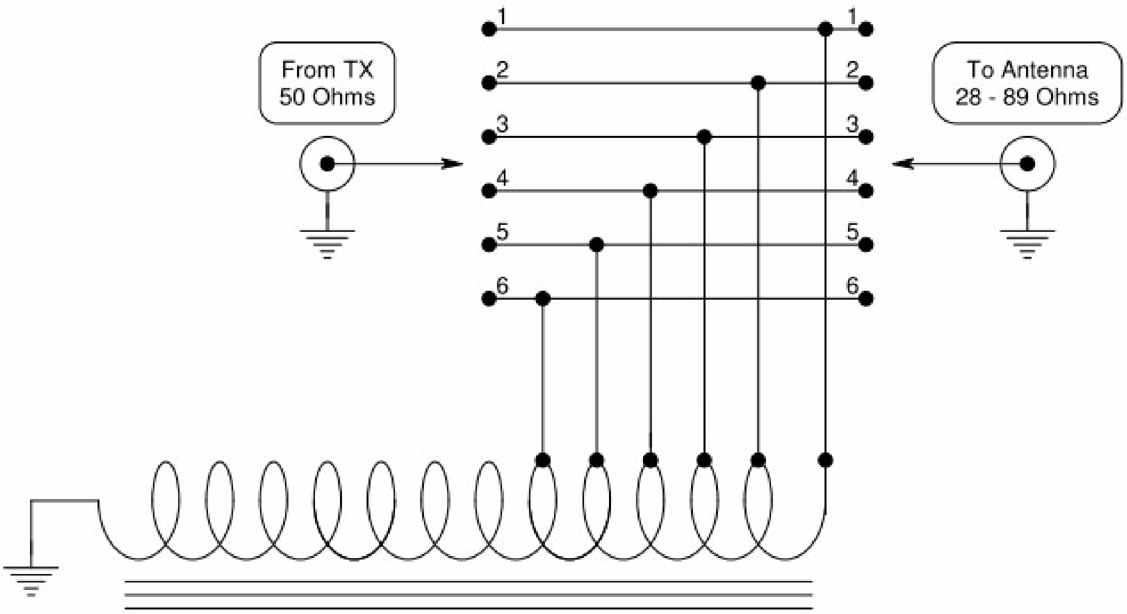
Inter-switch wiring using short leads.



The finished transformer installed in the RF network for the WD2XSH/7 600 Meter Station.

Note that the bar graph VSWR meter indicates 200 watts forward power and zero watts reflected power.

[Click here for a PDF copy of the Schematic Diagram]



EE80 - TSF7070 Ferrite Core Transformer, 20 turns #14 THHN solid copper wire.
Taps at turns 15, 16, 17, 18, 19, and 20.

FERRITE CORE DATA

E-80 - EE80 Ferrite E-Cores

Permeability = 3000

B(sat) = 500 mT

Dimensions: 80mm x 38mm x 20mm each half.

Magnetic Path length: 18.43 cm

Eff. Core Area: 3.93 cm ^2

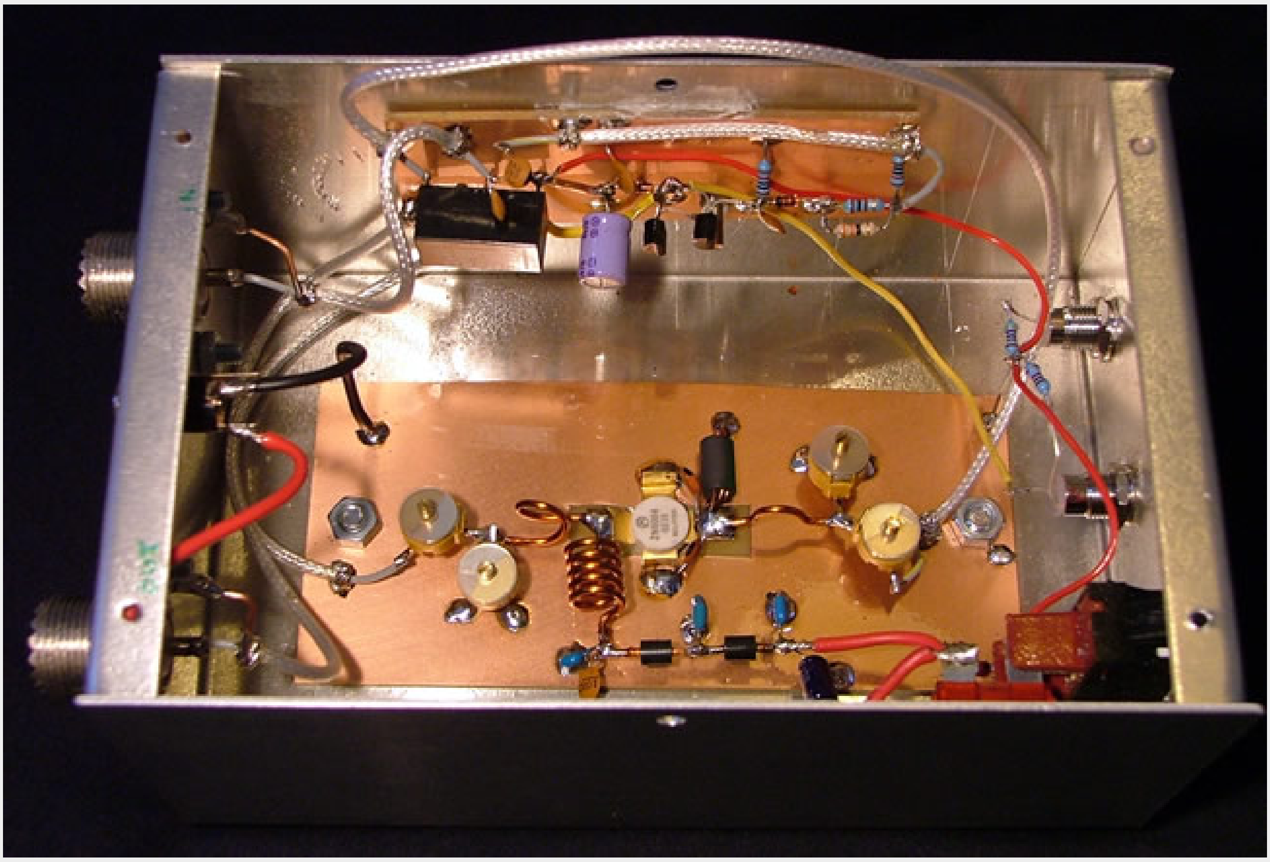
Eff. Core Volume: 36.20 cm ^3

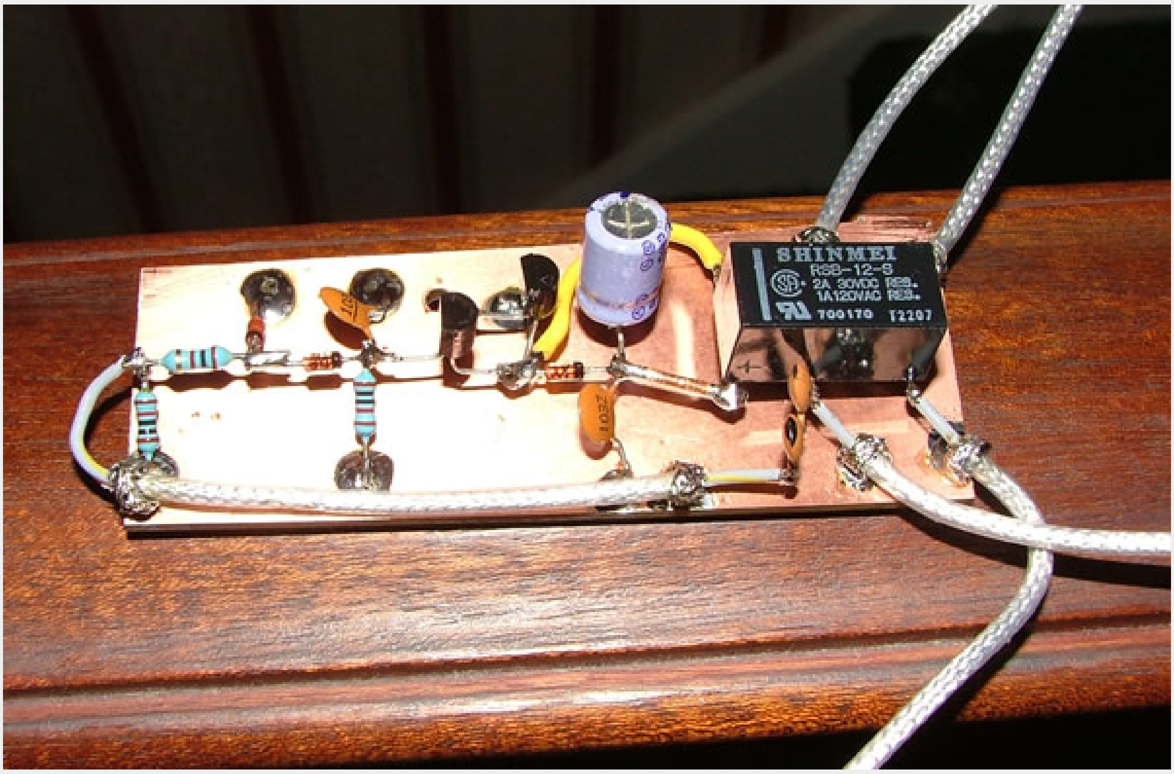
Power Handling capability index (WaAe) 44.69 cm^4

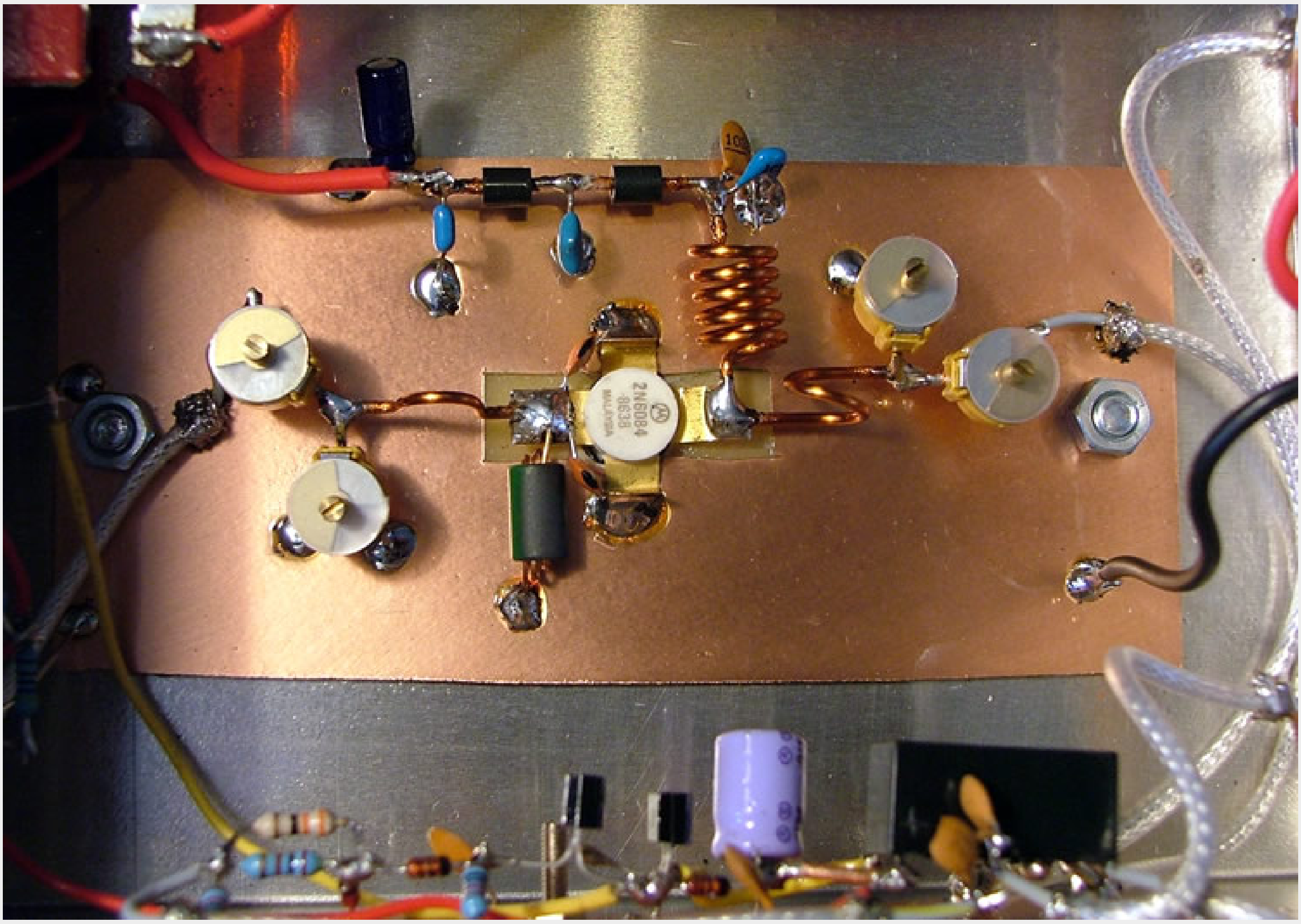
Inductance (AL): 8910 nH/N^2

Material: ASTM P7070 (TSF7070) ferrite

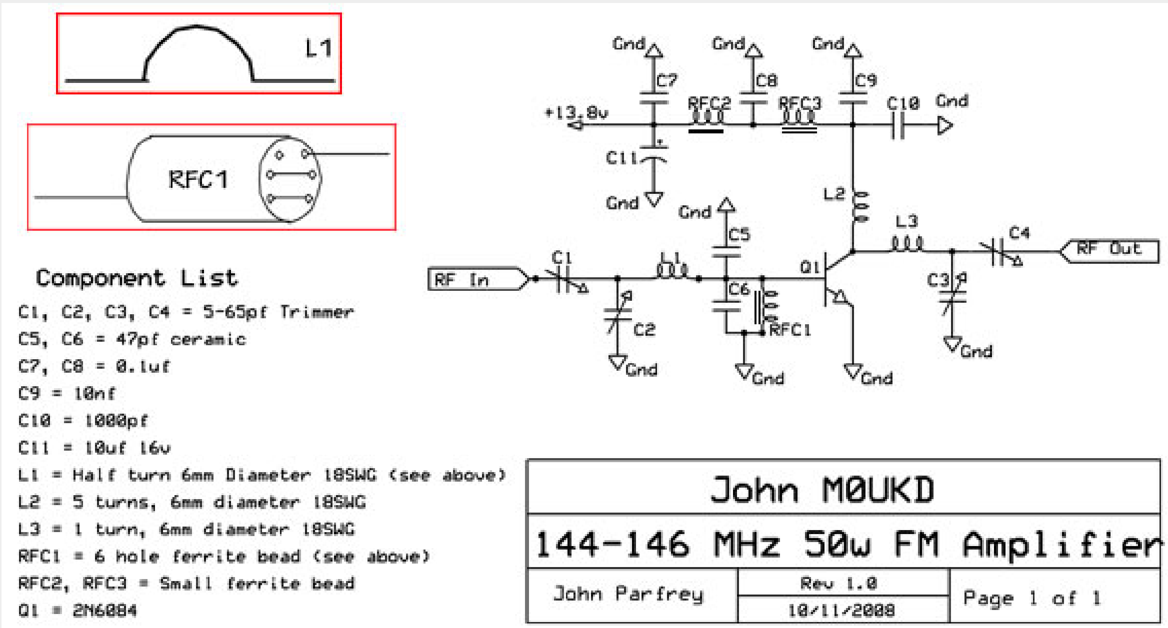
2N6084 144MHz FM Power Amplifier

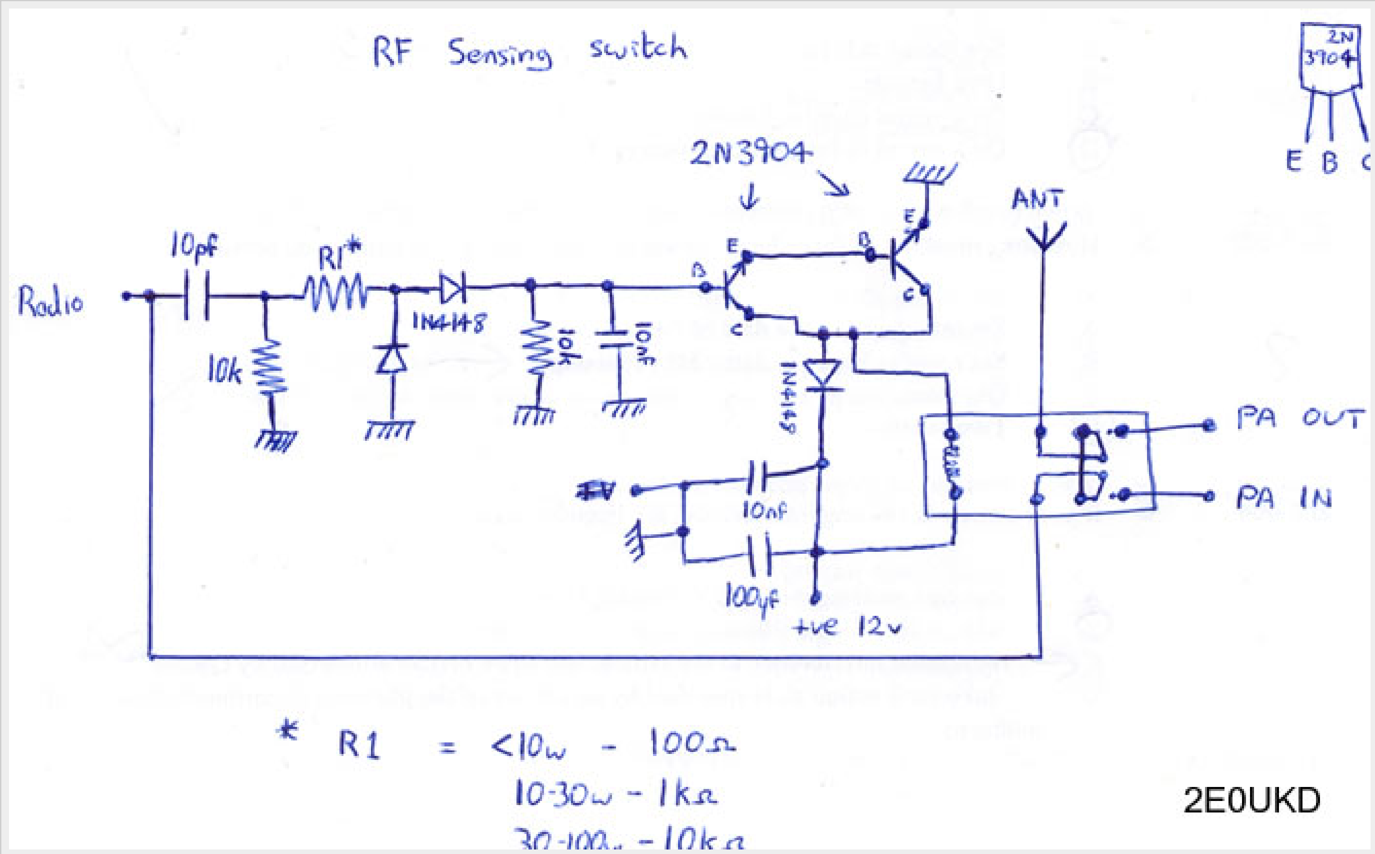



SHINMEI
RSB-12-S
2A 30VDC RES.
1A120VAC RES.


2N6084


OUT
IN


L1
RFC1
Component List
C1, C2, C3, C4 = 5-65pf Trimmer
C5, C6 = 47pf ceramic
C7, C8 = 0.1uf
C9 = 10nf
C10 = 1000pf
C11 = 10uf 16v
L1 = Half turn 6mm Diameter 18SWG (see above)
L2 = 5 turns, 6mm diameter 18SWG
L3 = 1 turn, 6mm diameter 18SWG
RFC1 = 6 hole ferrite bead (see above)
RFC2, RFC3 = Small ferrite bead
Q1 = 2N6084
+13.8v
Gnd
C7
C8
C9
C10
C11
RFC2
RFC3
L2
L3
C4
RF Out
RF In
C1
L1
C5
C6
Q1
C2
C3
RFC1
John M0UKD
144-146 MHz 50w FM Amplifier
John Parfrey
Rev 1.0
10/11/2008
Page 1 of 1


RF Sensing switch
2N3904
2N 3904
E B C
ANT
Radio
10pf
R1*
1N4148
10k
10k
10nF
1N4148
PA OUT
PA IN
10nF
100µF
+ve 12v
* R1 = <10w - 100Ω
10-30w - 1kΩ
30-100w - 10kΩ
2E0UKD

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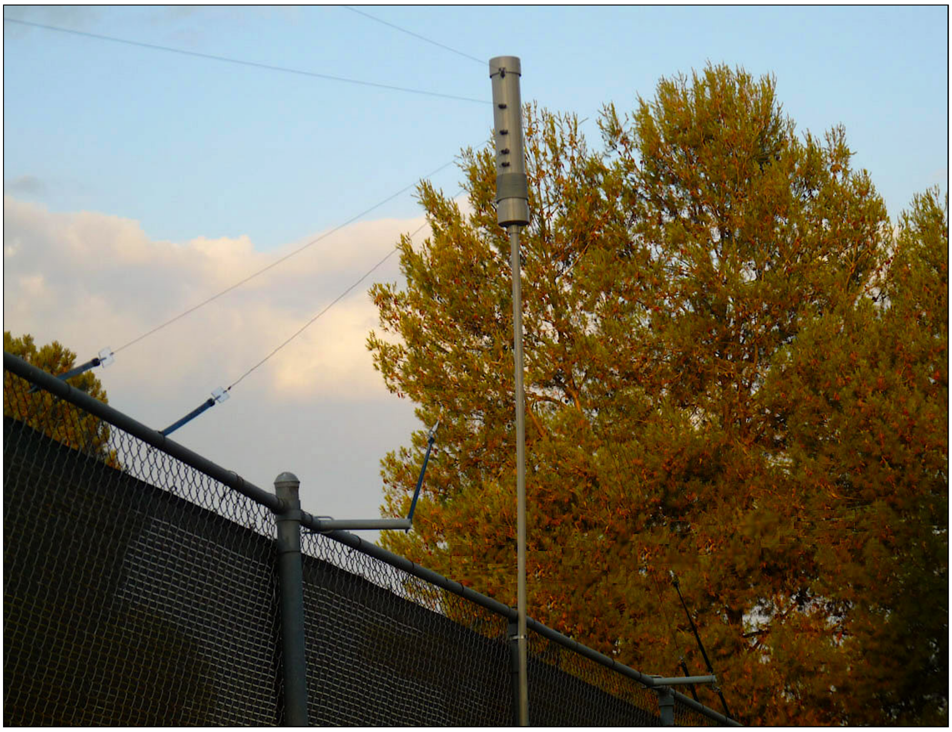
The Fence Fan Dipole (FFD)
A Quick, Easy and Inexpensive Multiband Antenna

By W6HDG

(Article courtesy of W6HDG and originally posted on eham.net here , July 26, 2012.

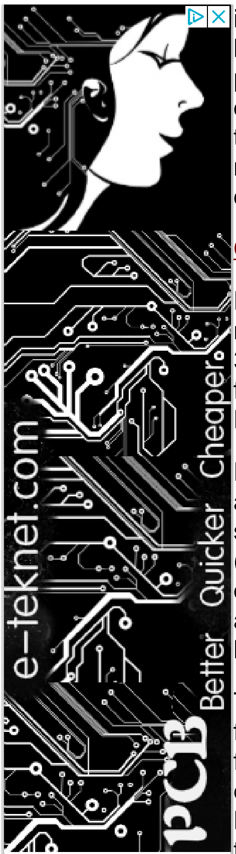
(Updated March, 2013 - See bottom of article)



Background

The multiband fan dipole has always been a popular antenna choice for getting on several bands with a single feedline and without the need for an antenna tuner. The height is limited only by the nearest tall tree and the cost of the antenna is minimal. The antenna is also rather stealthy - especially if 16-18 gauge wire can be used in sub 200 watt installations. The antenna basically consists of two to five or more distinct half wave dipoles which are mounted to a common parallel feedpoint so that a singe feedline can be utilized. Some nice designs are easy to find on the internet or in antenna handbooks. Most designs now suggest (based on Stanford Research Institute data) that the feedpoint be separated by as much as 5.5 inches between dipoles and that the lower frequency (longer) dipoles can be about 4% shorter than the 468/frequency in Mhz would dictate whereas the higher frequency (shorter) dipoles need to be about 4% longer. Many designs also recommend the controversial "ugly balun" choke in the design which is nothing more than 18-21 feet of coax close wound on a 4" or greater non-conductive form at the feedpoint.

There are certain downsides of the traditional fan dipole in that the top wire must often support the entire weight of the antenna as well as the balun. The need to ideally spread out the feedpoints by up to 5.5 inches also makes the feedpoint area rather cumbersome. Complicated spreaders must also be used in order to keep each dipole taut and well separated when there are only 2 end attachment points. There also can be some interaction among the dipoles and some detuning may occur if a dipole is



included which is a frequency multiple of 3 from a longer dipole in the system (3rd harmonic). For example a 30 meter, 15 meter and 6 meter 1/2 wave dipole may not be possible if an 80 meter, 40 meter and 17 meter dipole exists. A possible match may be obtained on 30 meters, 15 meters and 6 meters using the existing longer dipole but testing is required. Finally, it is difficult to trim and tune the antenna, since a single rope or rope-pulley system supports the entire array and it must be completely taken down for wire tuning or repair.

Objective

I am just getting back on HF after a few year hiatus and have moved to a neighborhood with some antenna restrictions. My rig is a Yaesu FT-857D and Astron 30 amp power supply. I have no tall trees on the property but do have one large feature on the property - a 45 year old tennis court with 12 foot fencing all around it. Each long side of the fencing is 120 feet total (a nice sounding number to dipole fans).

I decided to try an inexpensive antenna design as a starting point "just to get on the air". I figured that if I lashed a 10 section of schedule 40 PVC pipe to a central fence support with hose clamps, I could get an inverted-V up at around 20 feet at the center (not an ideal height for DX, but certainly usable). I then figured that I could use the dipoles themselves as "guys" for the central support if at least two of the dipoles were attached on a short offset support on both sides of the fence. The other dipoles could be "bungeed" directly to the fence mesh to keep them taut.

The advantages of my Fence Fan Dipole (FFD) design is that just about any sturdy fence that spans the linear distance of the lowest band can be used. The center feedpoint and balun can be made from a single two foot section of 4" drainpipe with end caps for weather resistance. This could be attached and supported atop a central PVC support pipe with appropriate threaded plumbing adapter and an electrical metal threaded nut available at most hardware stores. See construction images below. Each dipole is separately lashed to the fence with a bungee-like tarp strap so individual band tuning does not require entire antenna takedown. Dipoles can be easy attached and changed at the retention/ relief posts along the drainpipe for testing, experimenting and possible future repairs. Finally, excellent spreader distances between dipoles at each endpoint can be achieved.

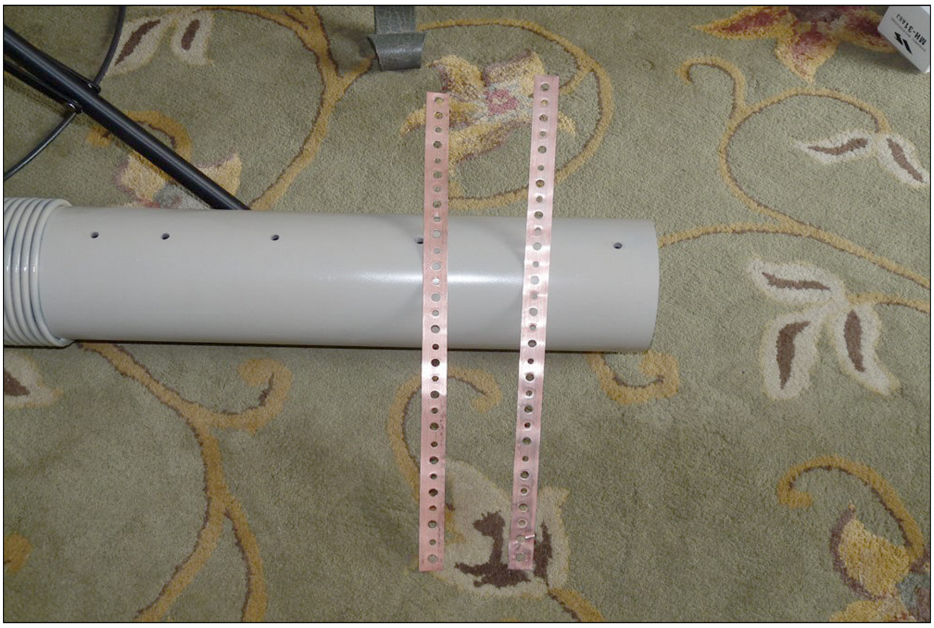
Construction

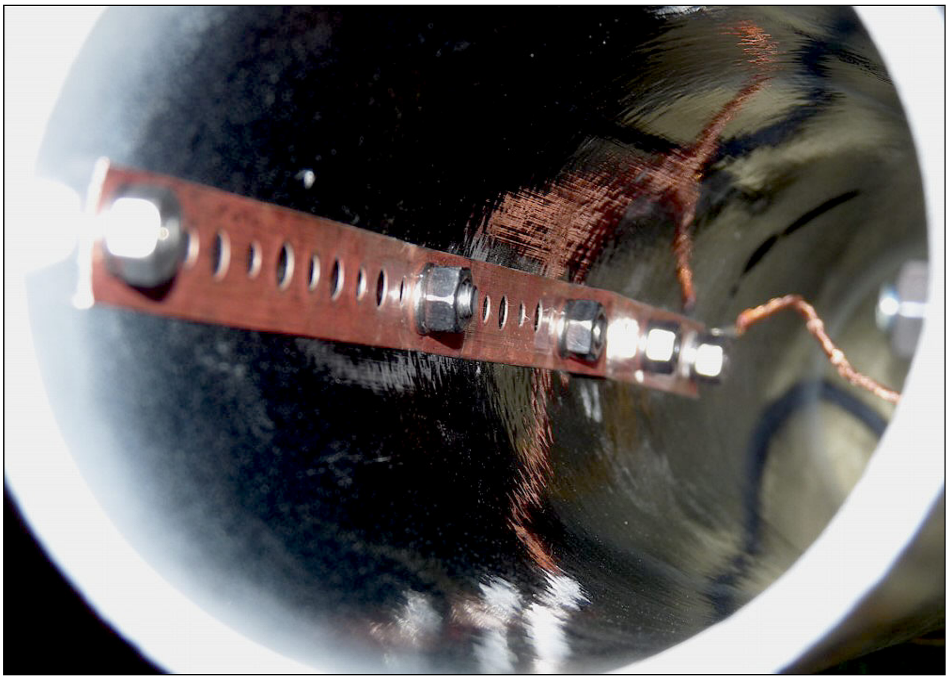
RG-8X coax and PL-259 connectors with adapters were the only ham radio specific parts.
The remaining parts were all obtained during a couple of trips the nearest Home Depot:

1) 18 gauge bare stranded copper "ground" wire is about $17 for 250 feet and worked extremely well. The 250 feet was just a few feet short for all dipoles so I made my 17 meter dipole from heavier bare copper stranded antenna wire I had on hand. If any of the copper is tarnished, it can be quickly rejuvenated by soaking in a few of ounces of vinegar with a half teaspoon of salt added. This allows the copper to be solder-ready in the necessary spots.

2) Two foot section of 4" ABS drain pipe with 2 end caps
3) Ten foot section of 1 inch schedule 40 PVC with threaded PVC adapter and a metal retention nut sold in the electrical section for threaded pipe. Three hose clamps to attach the PVC to a vertical member of the fence post
4) Copper clad plumbing strapping, copper electrical lugs with setscrews (Burndy KA4CBAG2R), Ten 1/4 inch x 1.5 inch eye bolts, two solder lugs for coax attachment, ten 1/4 inch lock washers and a total of twenty 1/4 inch nuts (ten of which are included with the eye bolts)
5) Four short 18 inch pieces of PVC to be use as fence "guy" standoffs along with four U-Bolts for attachment - see close-up image.
6) Ten tarp straps (bungee cords)
7) 10 Plexiglas rectangles prepared from a single 12"x12" sheet of 1/8" Plexiglas. Each rectangle about 3 inches by 1.5 inches with holes drilled on each long end

Note: I used coax-seal on the copper lugs to cover the set screws.



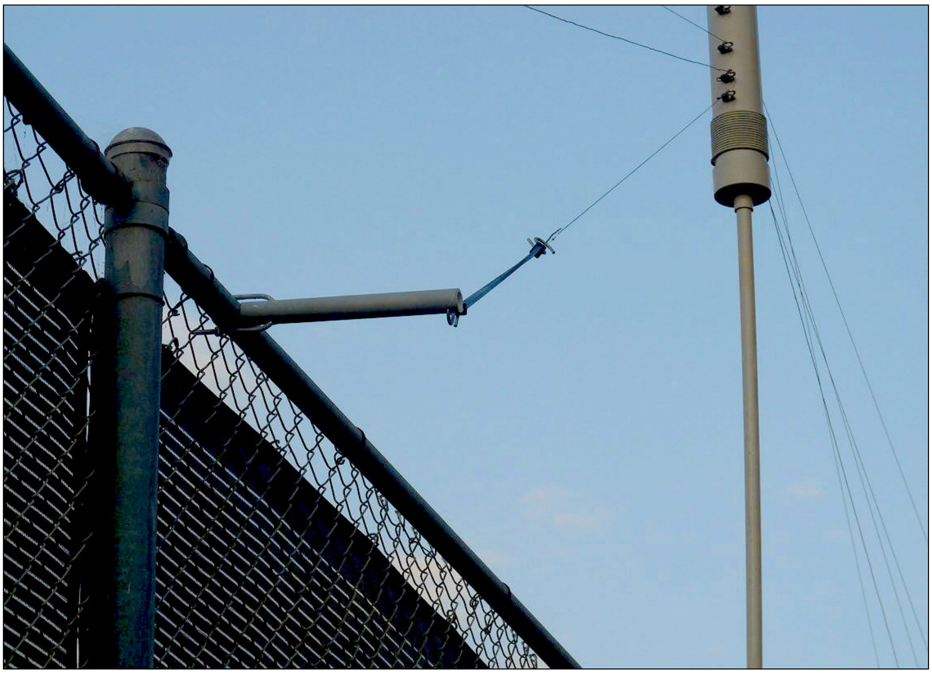


Construction is quite straightforward if you study the images above. I separated the 80 and 40 meter dipole eyebolts by the full 5.5 inches. I compromised and separated the 40 and 20 meter dipoles by 4.5 inches, 20 and 17 meter dipoles by 3.5 inches and the 17 and 10 meter dipoles by 3 inches. Each of two copper clad straps run the length of eyebolts along the inside of the ABS pipe. The coax lugs are attached at the eyebolts closest to the "ugly balun". Lock washers are used between the interior nut and the copper strapping. The balun itself is about 16 turns of RG-8X (21 feet) with epoxy used to seal the two inlets. The RG-8X then runs down the inside of the PVC support pipe. I used a barrel SO-239 at the bottom of the support pipe for convenience. I painted the coax, the ABS pipe and PVC all brown to keep things stealth.

Center insulator showing air wound choke (ugly balun). See update below!

A note about using two of the dipoles as "guys" to keep the flimsy PVC support pipe upright: If I had bungeed all dipoles to the fence mesh itself, I would not have had support in the "Y" plane to keep the PVC support pipe upright. I could have used two

opposing rope guys for this purpose, but didn't want to have any ground mounted supports. So I fashioned 18 inch fence top extenders by grinding a corresponding arc in an end of a piece of PVC and used a U-Bolt through the PVC to create a sturdy standoff from the fence. Good "Y" plane support can be achieved by bungeeing two of the shorter dipoles on each side of the fence with these extenders. This has kept the central PVC pipe quite vertical with resistance to winds we have seen to date.



The completed antenna is so stealth, it is quite hard to photograph as shown below. Hopefully this image with give you a good idea of the appearance of the support and at least of 3 of the 5 dipoles.

Dipole lengths, after adjusting some of the dipoles with the help of an MFJ-259 antenna analyzer were approximately:

80 meters: 61 feet each side including the loop between setscrew and eyebolt
40 meters: 32.8 feet each side including the loop between setscrew and eyebolt
20 meters: 17 feet each side including the loop between setscrew and eyebolt

17 meters: 13.6 feet each side including the loop between setscrew and eyebolt
10 meters: 8.6 feet each side including the loop between setscrew and eyebolt

Results

The FFD has obvious downsides - non-portability, height compromises and possible interaction with the fence if it is metal.

But initial testing has been quite good. During an hour of operating the IARU HF championship July 14-15, 2012, I worked 6 countries on 4 bands including Aruba, South Cook Island, Japan, Argentina, Canada and Mexico.

The antenna has acceptable SWR on 80, 40, 20, 17, 10 and 6 meters and contacts were made on all bands without an antenna tuner. 15 meters is usable.

SWR results were as follows:

3.8 Mhz 1.9 (SWR was 2.5 at 3.70, 2.5 at 3.9 and 3.8 at 4.0)
7.2 Mhz 1.3 (SWR was under 2.0 across entire band except 2.6 at 7.00)
14.13 Mhz 1.0 (SWR was under 1.5 across entire band)
18.14 Mhz 1.0 and same across entire band
21.3 Mhz 2.9 and same across entire band
28.5 Mhz 1.2 (SWR was under 2.0 across entire band except 2.2 at 29.7)
52 Mhz 1.4 (SWR was under 1.8 across entire 4 Mhz of the band)

I may add a tuner to get a better match on 15 meters and more bandwidth on 80 meters. It is unclear if a dedicated 15 meter dipole would have worked fine or if there would have been detuning - I haven't tried it.

I have no illusions about DX worthiness of this antenna. But dipoles and inverted-V's can make good antennas --especially on the lower frequencies where multi-element antennas are not practical. The multiband variety of the dipole such as that described here, when well tuned, should not suffer appreciably in performance over a monoband dipole at similar height. The advantages of a single feedline cannot be overemphasized.

Update - March 2013

I have been very happy with the Fence Fan Dipole I first erected in July 2012, but wanted to increase the height of the central support above the original 20 feet. I had also received a few reports of some RF in my transmit audio and decided that I wanted to add a real 1:1 balun at the feedpoint.

The "Ugly Balun" choke type balun used in the original installation using coax windings is great for a single band antenna, but the number of turns determines its effective choke frequency - so it is impossible to cover 80 through 6 meters with one coil of coax. I had heard wonderful reports of the baluns designed by the late Jerry Sevick W2FMI. These designs were now being made by Mike Lapuzza, KM5QX who runs Clear Signal Products at website www.coaxman.com. Mike was kind enough to make a special version of his 823A balun without the eyebolts so that it would fit inside my PVC drainpipe (see original article). This fit inside the pipe at the same location where the external coax windings were removed ***in the original article above.*** The balun worked like a charm and I have since received nothing but great audio reports - even after adding an Elecraft KPA500/KAT500 amp/tuner combo to my station. Mike hand makes the baluns, so he is very open to special orders like mine.

In researching lightweight support poles, I found John at http://goverticalusa.com. John sells new and used surplus military style fiberglass and aluminum 4 foot mating mast sections. The aluminum and fiberglas poles can be used in combination and fit together perfectly. To get to my goal height of 36 feet, I decided to use 6 stiffer aluminum sections for the lower mast and 3 fiberglass sections for the upper mast. My reason for using fiberglass was so that there were no metal sections at the top to interfere electrically with the dipoles. John also makes a very nice guy ring which can be inserted at any joint in the sections.

The guy ring.

I placed the guy ring shown in the photo above at 24 feet so that I could guy the mast at that point using some Dacron rope. I fashioned two additional 3/4 inch PVC outriggers to the fence to support the ropes from this guy ring in a 360 degree fashion (see final antenna picture). Remember, my lowest 12 feet of mast was solidly supported by hose clamps along the 12 foot high tennis fence. At the top (36 feet), the antenna would be "guyed" in the same way it had always been, by attaching the dipoles to the fence top with tarp style bungee straps (using some PVC outrigger poles at the fence top to keep the antenna balanced at the vertical). With the increased height, I now needed to add some Dacron ropes to some of the dipoles to fan them out properly along the fence.

Final Antenna Installation. Notice fence top near bottom of picture.

The result has been worth the effort. The only downside of the increased height is that the entire mast would need to be lowered for any work to be done on the antenna's individual dipoles. You can't tilt over 36 feet of military poles without damaging them,

so the antenna must come down the same way it went up - by removing (adding) one section at a time from the bottom as you slide the pole down (up) through the loosened hose clamps. Not very elegant but doable with a couple of people.

Since the original article was published, several hams have written with positive experiences. One ham fashioned 8 dipoles with one feedline for multiple bands including 15 meters and said that he did not have an issue with both a 40 and 15 meter dipole coexisting (3rd harmonic could cause both dipoles to potentially radiate). So experimentation is the name of the game with this antenna design.

Howard W6HDG

Questions? Email Howard, W6HDG AT arrl.net **>>>** (remove the AT and replace with **@**)

References

A Field Guide to Simple HF Dipoles, Cecil Barnes, et al, Standford Research Institute, Mar 1967, see
http://www.scribd.com/doc/50272493/A-FIELD-GUIDE-TO-SIMPLE-HF-DIPOLES

KJIIF, "The KJ4IIF Multiband "FAN" Dipole for 160, 80 and 40 Meters", see
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Paul Coats, AE5JU, Morgan City, LA "From Shortwave Listener to Extra Class" -
http://www.hamuniverse.com/ae5jumultibanddipole.html

N4UJW, "BUILD THIS MULTIBAND FAN DIPOLE FOR ALL BAND HF ANTENNA EXCITEMENT", Sept 2010, see
http://www.hamuniverse.com/multidipole.html

Build an "Ugly Balun" see this link for many ideas.

Editor's note: The "Ugly Balun" is not actually a balun, it is an air wound rf choke. Most hams call it "Ugly" because that is what their XYL's call it! HI HI.

ON6MU

Long Wave, Medium Wave and Shortwave Radio Experiments

1) Attempt to make a general coverage receiver (RE-RX1LM/HF)

LW, MW and SW bands

 rev1.1

About RX1LM/HF

This is a compact three transistor regenerative general coverage receiver with fixed feedback. It's based on the principle of the ZN414 only it can handle higher coverage. The sensitivity and selectivity is relative good (especially on the LF and MW bands) as can be expected with this "simple" design. The reception on the broadcast bands, LW(longwave) & MW(mediumwave) needs no external antenna! Just a ferrite rod which can be recovered from an old portable MW/LW radio which tuned from approximately 540 - 1600kHz on MW and 140kHz-240kHz for LW. If you have an old MW/LW (portable) radio you'll wont need to make your own coils for those bands if you use those.

An AM radio receiver is fundamentally a very simple device. In its simplest form, a resonant circuit builds up a signal if there is one in space at the frequency to which it is tuned. A crystal (galena) then rectifies the signal, which reproduces the modulation. All the energy comes from the received electromagnetic wave. A good receiver must combine sensitivity and selectivity. Sensitivity is obtained by amplification in several stages, while selectivity is obtained by a narrow bandwidth of the amplifiers. There is a severe problem if the receiver must tune over a reasonable interval, such as the medium-wave broadcast band from 550 kHz to 1.65 MHz. The filters of the several stages of amplification cannot track well enough as their frequency is varied if the bandwidth is narrow, so one must choose between sensitivity and selectivity in such a tuned-RF receiver. There are other problems as well, such as the variation in selectivity as the circuits are tuned over a wide range.

It doesn't need a external power supply as the total current is very low (total 12mA) and can be fed with just 3 (chargeable) batteries. Transistor T3 has a dual purpose; it performs demodulation of the RF carrier whilst at the same time, amplifying the audio signal. Audio level varies on the strength of the received station but I had typically 10-40 mV. This will directly drive the TDA7052 and drives a 8 Ohm speaker up to 0.5 watt @ 3.6volts.
T1 and T2 form a compund transistor pair featuring high gain and very high input impedance. This is necessary so as not to unduly load the tank circuit. T1 operates in emitter follower, T2 common emitter, self stabilizing bias is via the 56k resistor, the 150pF capacitor and the tuning coil.

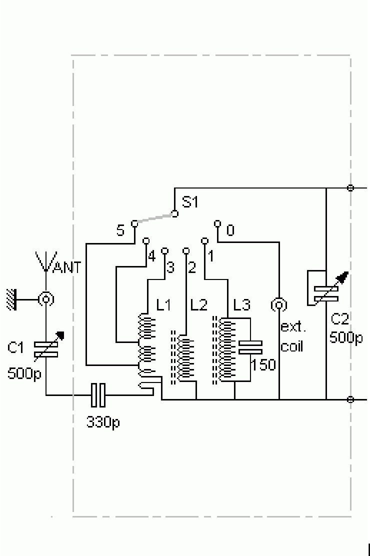
P1 set the audio volume.

All connections should be short, a veroboard or tagstrip layout are suitable. The tuning capacitor has fixed and moving plates where the moving plates should be connected to the "cold" end of the tank circuit, this is the base of T1, and the fixed plates to the "hot end" of the coil, the juction of 56k/150p/100n. If connections on the capacitor are reversed, then moving your hand near the capacitor will cause unwanted stability and oscillation.

Switch between the coils (being the frequency bands) with S1. The tapping points on the coil allow the set to be tuned to different frequencies by adjusting the position of tap-switch S1.

You can also replace the "RF amplifier/demodulator unit" with a ZN414/MK484 as shown on lower on this page but without the BC109 LF amp, or you can leave it and change the 10k pot with a 10k trim potentiometer to be able to adjust the volume that is fed to the TD7052. One thing though...The ZN414 does not handle LW very well (bad is more appropiate).

Shortwave?



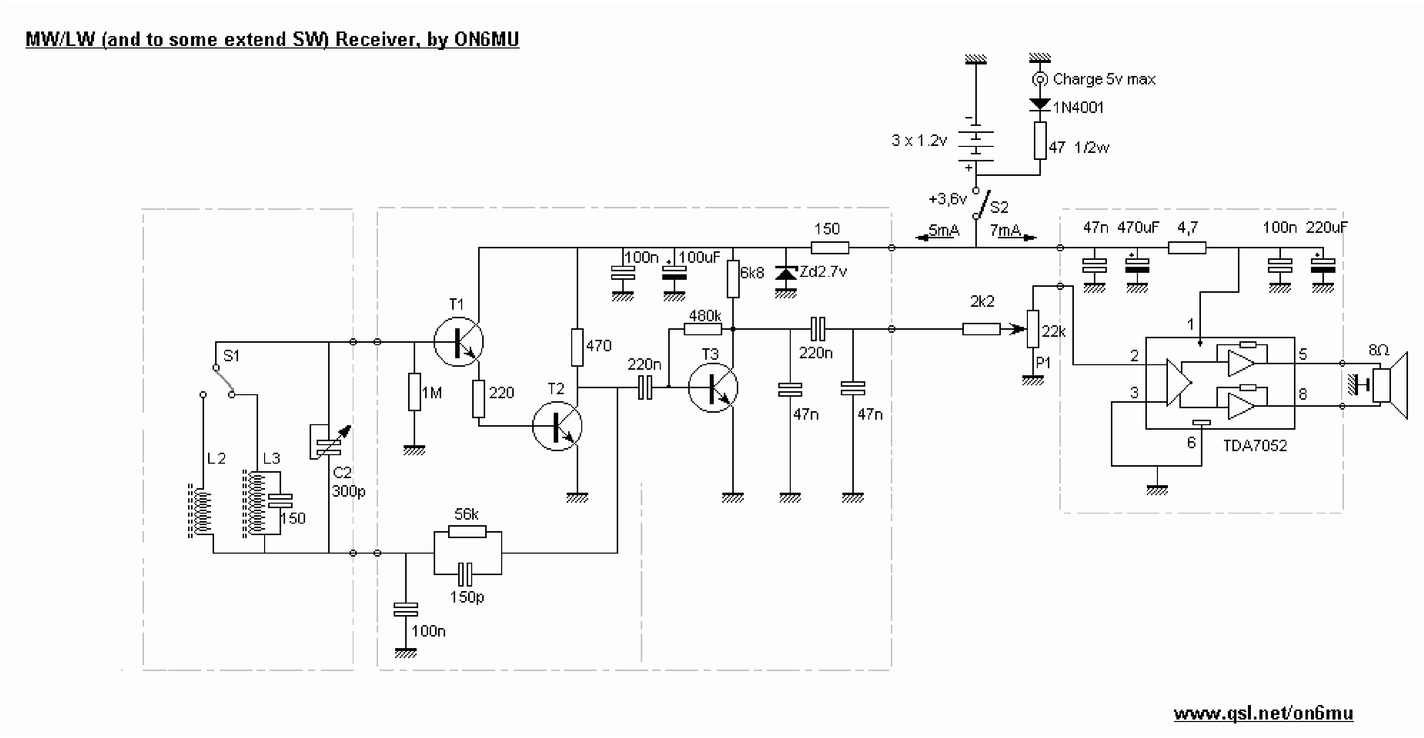
I have experimented with this radio and it could reach up to 24MHz. However, sensitivity and selectivity suffers as frequency goes up. It also needs an external antenna when wondering about on those shortwave frequencies. I would also recommend to use a variable C1 in series with the antenna connector to avoid the receiver being saturated at higher frequencies (shortwave) when using a longwire or any other "large" antenna that isn't resonant. Using a real antenna tuner would be even better... The sensitivity is not as good as on MW and LW though, nor is the selectivity. I've put a RCA/Cinch-connector (or better, a BNC-connector) at the band switch to allow experiments with different types of coils for different frequency ranges.

<u>Frequency coverage RX1LM/HF</u>
LW : 140 - 240 KHz (good)
MW: 520 -1600 KHz (good up to 3Mc)

Experimental:
SW1: 2500 - 6000 KHz (moderate)
SW2: 5 Mhz - 14 MHz (moderate)
SW3: 12 MHz - 24 MHz (low)

<u>Mode</u>: AM

Schematic



Tuning unit RF amplifier/demodulator unit LF output amplifier

Details - Coils

L2: 4 mH, 550 turns on a 9/10mm ferrite rod OR MW 'loopstick' antenna scrapped from an old transistor radio
L3: 310 uH, 65 turns on a 9/10mm ferrite rod OR LW 'loopstick' antenna also 'recycled' from an old transistor radio (both L2 and L3 are on the same ferrite core)

The loopstick antenna coil is best wound on a bit of cardboard or plastic tube around the ferrite rod. The coil can then be slid along the rod to adjust the tuning range. Use this to set the low-frequency end of the band. If you need to set the upper end of the band then place a capacitor across the tuning cap and re-adjust the low end of the band again (in schematic L3 150pF). Experiment.

S1: 2 way switch (MW/LW band selection)

For SW experiments:
**L1: total of 37 turns of 0.65mm on a 18mm diameter plastic tube of 30 mm height:*
taps at 24 turns, 8 turns, 3 turns, 2 turns

S1: 6 position rotary switch

Transistors
T1, T2, T3 = BC547 NPN

Specs

- Frequency range: 140 kHz - 3000 KHz (maximum limit 24 MHz). LW & MW bands needs no external antenna.
- U = 3...12 volts *Battery or external power operated
- 3 x 1.2 volt chargeable batteries
- I = 12mA @ 3.6volts
- Output LF power: 500mW @ 3.6volts, 1Watt @ 12 volts
- PL259 connector for external antenna (used for the shortwave bands)

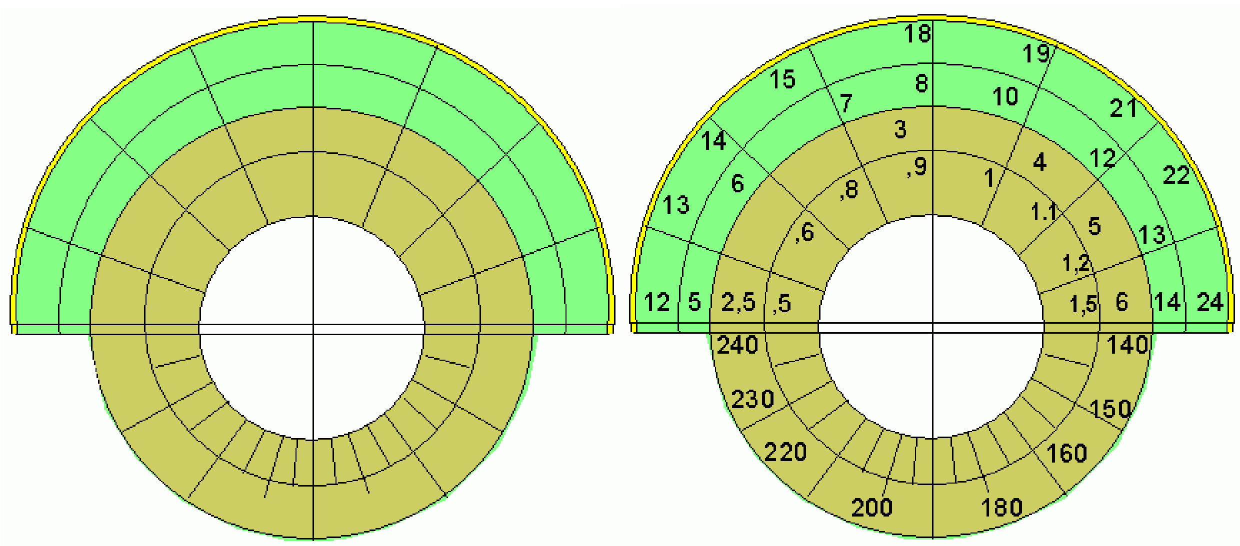
The receiver sensitivity and selectivity is more then fair on LW and MW bands up to 3Mc. However, the higher you go in frequency (> 3 Mhz) the less sensitivity and selectivity the radio will have. This could be improved by using a selective pre-amp between the shortwave bands (S1: position 3,4,5).

top view

Inside view 1

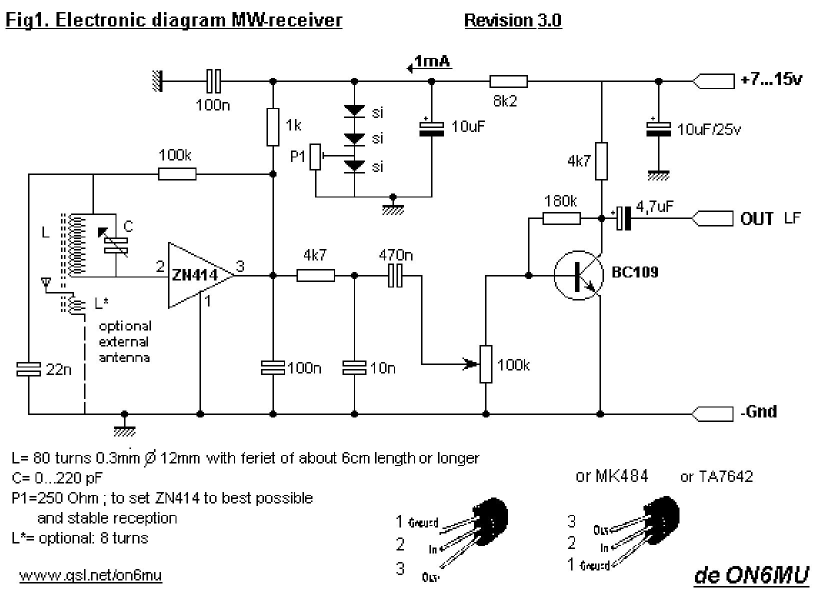
Inside view 2

Dial scale (with the SW experimental scales included)



More of my projects: [50 Mhz converter/receiver]

2) RE-RX2MW: MW receiver based upon a ZN414
(retired, but can be replaced by a much better MK484 or TA7642)



The MK484 easlily goes up to 3Mc and even somewhat beyond. Experiment with the [RX1LM/HF coils] on the top of this page!

AM radio is broadcast on several frequency bands:

Long wave is 153–279 kHz; it is not available far into the Western Hemisphere, and European 9 kHz channel spacing is generally used (historically frequencies as high as 413 kHz were used but currently there are no terrestrial LW broadcasters above 279 kHz).
Medium wave is 520–1,610 kHz. In the Americas (ITU region 2) 10 kHz spacing is used; elsewhere it is 9 kHz. ITU region 2 also authorizes the Extended AM broadcast band between 1610 and 1710 kHz.
Short wave is 2.3–26.1MHz, divided into 15 broadcast bands. Shortwave broadcasts generally use a narrow 5 kHz channel spacing.
The allocation of these bands is governed by the ITU's Radio Regulations and, on the national level, by each country's telecommunications administration (the FCC in the U.S., for example) subject to international agreements.

Long wave is used for radio broadcasting in Europe, Africa, Oceania and parts of Asia (ITU regions 1 and 3). In the United States and Canada, Bermuda and U.S. territories this band is mainly reserved for aeronautics, though a small section of the band could theoretically be used for microbroadcasting under the United States Part 15 rules. Due to the propagation characteristics of long wave signals, the frequencies are used most effectively in latitudes north of 50°.

Medium wave is by far the most heavily used band for commercial broadcasting. This is the "AM radio" that most people are familiar with.

Short wave is used by audio services intended to be heard at great distances from the transmitting station. The long range of short wave broadcasts comes at the expense of lower audio fidelity. The mode of propagation for short wave is different (see high frequency). AM is used mostly by broadcast services — other shortwave users may use

a modified version of AM such as SSB or an AM-compatible version of SSB such as SSB with carrier reinserted. In many parts of the world short wave radio also carries audible, encoded messages of unknown purpose from numbers stations.

Frequencies between the broadcast bands are used for other forms of radio communication, such as baby monitors, walkie talkies, cordless telephones, radio control, "ham" radio, etc.

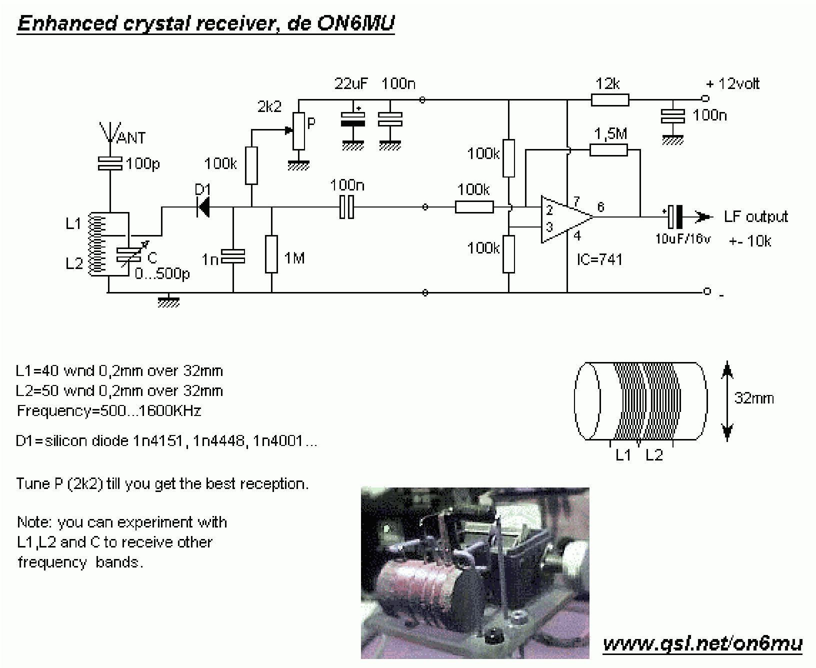
AM radio signals can be severely disrupted in large urban centres by concrete bridges with metal reinforcements, other Faraday cage structures, tall buildings and sources of radio frequency interference (RFI) and electrical noise, such as electrical motors, fluorescent lights, traffic signals, or lightning. As a result, AM radio in many countries has lost its dominance as a music broadcasting service, and in many cities is now relegated to news, sports, religious and talk radio stations although some musical genres — particularly country, oldies, nostalgia and ethnic/world music — survive on AM, especially in areas where FM frequencies are in short supply or in thinly populated or mountainous areas where FM coverage is poor.

Also more of my homebrew projects:

ON6MU Homebrew projects
Radioamateur related projects

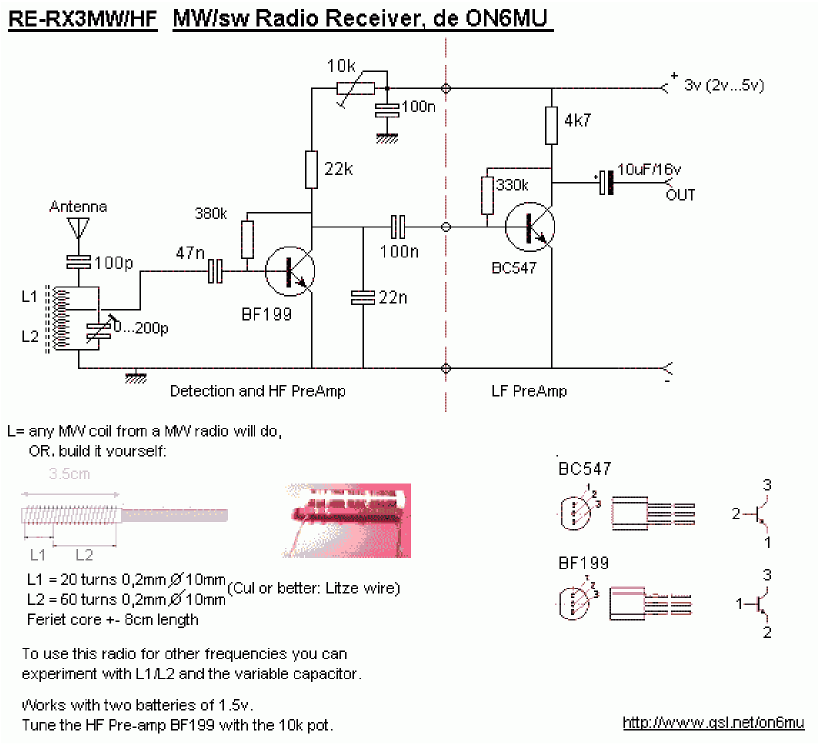
ON6MU Ham mods
Modifications of transceivers

3) RE-RX1MW: Enhanced Crystal MW Receiver



3) RE-RX3MW/HF: Enhanced Crystal MW/SW Receiver

(using one transistor for HF amplification and detection)



73"

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Single-wire earth return

Single-wire earth return (**SWER**) or **single-wire ground return** is a single-wire transmission line which supplies single-phase electric power from an electrical grid to remote areas at low cost. Its distinguishing feature is that the earth (or sometimes a body of water) is used as the return path for the current, to avoid the need for a second wire (or *neutral wire*) to act as a return path.

SWER power line in Queensland

Single-wire earth return is principally used for rural electrification, but also finds use for larger isolated loads such as water pumps. It is also used for high-voltage direct current over submarine power cables. Electric single-phase railway traction, such as light rail, uses a very similar system. It uses resistors to earth to reduce hazards from rail voltages, but the primary return currents are through the rails.[1]

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Description

Mechanical design

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- Cost advantages
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- Upgradeability
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- In HVDC systems

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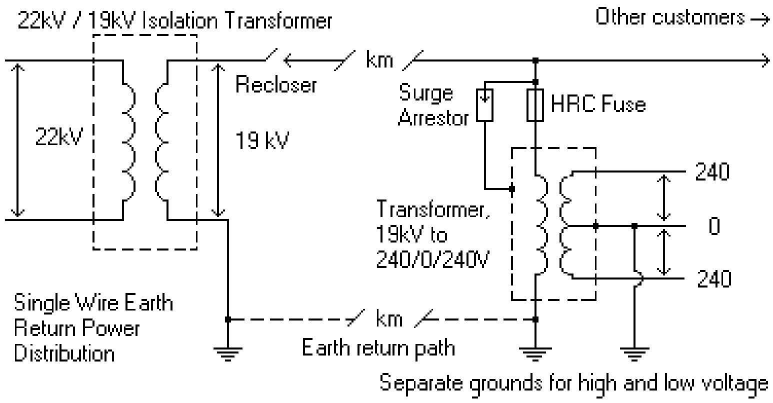
History

Lloyd Mandeno, OBE (1888–1973) fully developed SWER in New Zealand around 1925 for rural electrification. Although he termed it "Earth Working Single Wire Line", it was often called "Mandeno's Clothesline".[2] More than 200,000 kilometres have now been installed in Australia and New Zealand. It is considered safe, reliable and low cost, provided that safety features and earthing are correctly installed. The Australian standards are widely used and cited. It has been applied around the world, such as in the Canadian province of Saskatchewan; Brazil; Africa; and portions of the United States' Upper Midwest and Alaska (Bethel).

Description

SWER is a viable choice for a distribution system when conventional return current wiring would cost more than SWER's isolation transformers and small power losses. Power engineers experienced with both SWER and conventional power lines rate SWER as equally safe, more reliable, less costly, but with slightly lower efficiency than conventional lines.[3] SWER can cause fires when maintenance is poor, and bushfire is a risk.[4]



Power is supplied to the SWER line by an isolating transformer of up to 300 kVA. This transformer isolates the grid from ground or earth, and changes the grid voltage (typically 22 or 33 kV line-to-line) to the SWER voltage (typically 12.7 or 19.1 kV line-to-earth).

The SWER line is a single conductor that may stretch for tens or even hundreds of kilometres, with a number of distribution transformers along its length. At each transformer, such as a customer's premises, current flows from the line, through the primary coil of a step-down isolation transformer, to earth through an earth stake. From the earth stake, the current eventually finds its way back to the main step-up transformer at the head of the line, completing the circuit.[3] SWER is therefore a practical example of a phantom loop.

In areas with high-resistance soil, the resistance of the soil wastes energy. Another issue is that the resistance may be high enough that insufficient current flows into the earth neutral, causing the grounding rod to float to higher voltages. Self-resetting circuit breakers usually reset because of a difference in voltage between line and neutral. Therefore, with dry, high-resistance soils, the reduced difference in voltage between line and neutral may prevent breakers from resetting. In Australia, locations with very dry soils need the grounding rods to be extra deep.[5] Experience in Alaska shows that SWER needs to be grounded below permafrost, which is high-resistance.[6]

The secondary winding of the local transformer will supply the customer with either single ended single phase (N-0) or split phase (N-0-N) power in the region's standard appliance voltages, with the 0 volt line connected to a safety earth that does not normally carry an operating current.

A large SWER line may feed as many as 80 distribution transformers. The transformers are usually rated at 5 kVA, 10 kVA and 25 kVA. The load densities are usually below 0.5 kVA per kilometer (0.8 kVA per mile) of line. Any single customer's maximum demand will typically be less than 3.5 kVA, but larger loads up to the capacity of the distribution transformer can also be supplied.

Some SWER systems in the USA are conventional distribution feeders that were built without a continuous neutral (some of which were obsoleted transmission lines that were refitted for rural distribution service). The substation feeding such lines has a grounding rod on each pole within the substation; then on each branch from the line, the span between the pole next to and the pole carrying the transformer would have a grounded conductor (giving each transformer two grounding points for safety reasons).

Mechanical design

Proper mechanical design of a SWER line can lower its lifetime cost and increase its safety.

Since the line is high voltage, with small currents, the conductor used in historic SWER lines was 8-gauge galvanized steel fence wire. More modern installations use specially-designed AS1222.1[7][8] high-carbon steel, aluminum-clad wires. Aluminum clad wires corrode in coastal areas, but are otherwise more suitable.[9] Because of the long spans and high mechanical tensions, vibration from wind can cause damage to the wires. Modern systems install spiral vibration dampers on the wires.[9]

Insulators are often porcelain because polymers are prone to ultraviolet damage. Some utilities install higher-voltage insulators so the line can be easily upgraded to carry more power. For example, 12 kV lines may be insulated to 22 kV, or 19 kV lines to 33 kV.[9]

Reinforced concrete poles have been traditionally used in SWER lines because of their low cost, low maintenance, and resistance to water damage, termites and fungi. Local labor can produce them in most areas, further lowering costs. In New Zealand, metal poles are common (often being former rails from a railway line). Wooden poles are acceptable. In Mozambique, poles had to be at least 12 m (39 ft) high to permit safe passage of giraffes beneath the lines.[9]

If an area is prone to lightning, modern designs place lightning ground straps in the poles when they are constructed, before erection. The straps and wiring can be arranged to be a low-cost lightning arrestor with rounded edges to avoid attracting a lightning strike.[9]

Characteristics

Safety

SWER is promoted as safe due to isolation of the ground from both the generator and user. Most other electrical systems use a metallic neutral connected directly to the generator or a shared ground.[3]

Grounding is critical. Significant currents on the order of 8 amperes flow through the ground near the earth points. A good-quality earth connection is needed to prevent risk of electric shock due to earth potential rise near this point. Separate grounds for power and safety are also used. Duplication of the ground points assures that the system is still safe if either of the grounds is damaged.

A good earth connection is normally a 6 m stake of copper-clad steel driven vertically into the ground, and bonded to the transformer earth and tank. A good ground resistance is 5–10 ohms which can be measured using specialist earth test equipment. SWER systems are designed to limit the voltage in the earth to 20 volts per meter to avoid shocking people and animals that might be in the area.

Other standard features include automatic reclosing circuit breakers (reclosers). Most faults (overcurrent) are transient. Since the network is rural, most of these faults will be cleared by the recloser. Each service site needs a rewirable drop out fuse for protection and switching of the transformer. The transformer secondary should also be protected by a standard high-rupture capacity (HRC) fuse or low voltage circuit breaker. A surge arrestor (spark gap) on the high voltage side is common, especially in lightning-prone areas.

Most fire safety hazards in electrical distribution are from aging equipment: corroded lines, broken insulators, etc. The lower cost of SWER maintenance can reduce the cost of safe operation in these cases.[4]

SWER avoid lines clashing in wind, a substantial fire-safety feature,[4] but a problem surfaced in the official investigation into the Black Saturday bushfires in Victoria, Australia. These demonstrated that a broken SWER conductor can short to ground across a resistance similar to the circuit's normal load; in that particular case, a tree. This can cause large currents

without a ground-fault indication.[4] This can present a danger in fire-prone areas where a conductor may snap and current may arc through trees or dry grass.

Bare-wire or ground-return telecommunications can be compromised by the ground-return current if the grounding area is closer than 100 m or sinks more than 10 A of current. Modern radio, optic fibre channels, and cell phone systems are unaffected.

Many national electrical regulations (notably the U.S.) require a metallic return line from the load to the generator.[10] In these jurisdictions, each SWER line must be approved by exception.

Cost advantages

SWER's main advantage is its low cost. It is often used in sparsely populated areas where the cost of building an isolated distribution line cannot be justified. Capital costs are roughly 50% of an equivalent two-wire single-phase line. They can cost 30% of 3-wire three-phase systems. Maintenance costs are roughly 50% of an equivalent line.

SWER also reduces the largest cost of a distribution network, the number of poles. Conventional 2-wire or 3-wire distribution lines have a higher power transfer capacity, but can require 7 poles per kilometre, with spans of 100 to 150 metres. SWER's high line voltage and low current also permits the use of low-cost galvanized steel wire (historically, No. 8 fence wire).[9] Steel's greater strength permits spans of 400 metres or more, reducing the number of poles to 2.5 per kilometre.

If the poles also carry optical fiber cable for telecommunications (metal conductors may not be used), capital expenditures by the power company may be further reduced.

Reliability

SWER can be used in a grid or loop, but is usually arranged in a linear or radial layout to save costs. In the customary linear form, a single-point failure in a SWER line causes all customers further down the line to lose power. However, since it has fewer components in the field, SWER has less to fail. For example, since there is only one line, winds can't cause lines to clash, removing a source of damage, as well as a source of rural brush fires.

Since the bulk of the transmission line has low resistance attachments to earth, excessive ground currents from shorts and geomagnetic storms are more rare than in conventional metallic-return systems. So, SWER has fewer ground-fault circuit-breaker openings to interrupt service.[3]

Upgradeability

A well-designed SWER line can be substantially upgraded as demand grows without new poles.[11] The first step may be to replace the steel wire with more expensive copper-clad or aluminum-clad steel wire.

It may be possible to increase the voltage. Some distant SWER lines now operate at voltages as high as 35 kV. Normally this requires changing the insulators and transformers, but no new poles are needed.[12]

If more capacity is needed, a second SWER line can be run on the same poles to provide two SWER lines 180 degrees out of phase. This requires more insulators and wire, but doubles the power without doubling the poles. Many standard SWER poles have several bolt holes to support this upgrade. This configuration causes most ground currents to cancel, reducing shock hazards and interference with communication lines.

Two-phase service is also possible with a two-wire upgrade: Though less reliable, it is more efficient. As more power is needed, the lines can be upgraded to match the load, from single wire SWER to two wire, single phase and finally to three wire, three phase. This ensures a more efficient use of capital and makes the initial installation more affordable.

Customer equipment installed before these upgrades will all be single phase, and can be reused after the upgrade. If small amounts of three-phase power are needed, it can be economically synthesized from two-phase power with on-site equipment.

Power-quality weakness

SWER lines tend to be long, with high impedance, so the voltage drop along the line is often a problem, causing poor regulation. Variations in demand cause variation in the delivered voltage. To combat this, some installations have automatic variable transformers at the customer site to keep the received voltage within legal specifications.[13]

After some years of experience, the inventor advocated a capacitor in series with the ground of the main isolation transformer to counteract the inductive reactance of the transformers, wire and earth return path. The plan was to improve the power factor, reduce losses and improve voltage performance due to reactive power flow.[3] Though theoretically sound, this is not standard practice. It does also allow the use of a DC test loop, to distinguish a legitimate variable load from (for example) a fallen tree, which would be a DC path to ground.

Use

In addition to New Zealand and Australia, single-wire earth return is used throughout the globe.

Alaska

In 1981 a high-power 8.5 mile prototype SWER line was successfully installed from a diesel plant in Bethel to Napakiak in Alaska, United States. It operates at 80 kV, and was originally installed on special lightweight fiberglass poles that formed an A-frame. Since then, the A frames have been removed and standard wooden power poles were installed. The A-framed poles could be carried on lightweight snow machines, and could be installed with hand tools on permafrost without extensive digging. Erection of "anchoring" poles still required heavy machinery, but the cost savings were dramatic.

Researchers at the University of Alaska Fairbanks, United States estimate that a network of such lines, combined with coastal wind turbines, could substantially reduce rural Alaska's dependence on increasingly expensive diesel fuel for power generation.[14] Alaska's state economic energy screening survey advocated further study of this option to use more of the state's underutilized power sources.[15]

In developing nations

At present, certain developing nations have adopted SWER systems as their mains electricity systems, notably Laos, South Africa and Mozambique.[9] SWER is also used extensively in Brazil where it is termed "Redes Monofilares com Retorno por Terra" or "MRT". There are detailed standards and drawings available in Brazilian Portuguese that would be transferable to other Portuguese speaking countries such as Angola and Mozambique.[16]

In HVDC systems

Many high-voltage direct current systems (HVDC) using submarine power cables are single wire earth return systems. Bipolar systems with both positive and negative cables may also retain a seawater grounding electrode, used when one pole has failed. To avoid electrochemical corrosion, the ground electrodes of such systems are situated apart from the converter stations and not near the transmission cable.

The electrodes can be situated in the sea or on land. Bare copper wires can be used for cathodes, and graphite rods buried in the ground, or titanium grids in the sea are used for anodes. To avoid electrochemical corrosion (and passivation of titanium surfaces) the current density at the surface of the electrodes must be small, and therefore large electrodes are required.

Examples of HVDC systems with single wire earth return include the Baltic Cable and Kontek.

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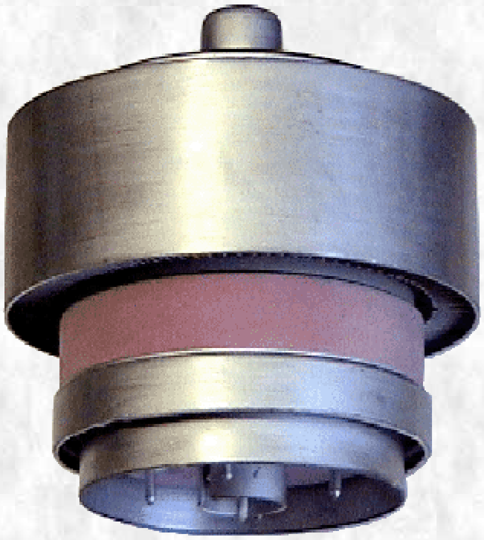
External links

- Rural power.org (http://www.ruralpower.org/); Excellent site on this topic. Provides the PDF of Mandeno's article.
- Manual for Single Wire Earth Return Power Systems (http://pwinternet.powerwater.com.au/_media/standard_drawings/power_supply_volumes/vol_25_-_single_wire_earth_return_line_manual) From the Network Power Standards Branch of the Australian Northern Territory Government. Includes dimensioned mechanical drawings and parts lists.
- AS2558-2006 Transformers for use on single-wire earth-return distribution systems (https://infostore.saiglobal.com/store/PreviewDoc.aspx?saleItemID=322001) - An Australian standard
- Saskatchewan in Canada has operated SWER for more than fifty years (http://www.saskpower.com/news_publications/annual_reports/2009/pdfs/AR2009_year_in_detail.pdf)
- Distributed generation as voltage support for single wire earth return systems, Kashem, M.A.; Ledwich, G.; IEEE Transactions on Power Delivery, Volume 19, Issue 3, July 2004 Page(s): 1002 - 1011 [2] (http://ieeexplore.ieee.org/Xplore/login.jsp?url=/iel5/61/29033/01308320.pdf?tp=&arnumber=1308320&isnumber=29033)

QRO GU-84B TETRODE



PLEASE LET IT LOAD TO VIEW ALL THE PICS.

4CX2500A/GU-84B

SVETLANA POWER TRANSMITTING TETRODE

The GU-84B is a ceramic-metal forced-air cooled tetrode intended for use in power amplifiers with distributed amplification and for SSB-signal amplification with output power up to 2.5 kW at frequencies up to 75 MHz as well as for power amplification at frequencies up to 250 MHz with output power up to 2.2 kW in radiotechnical equipment. The Svetlana 4CX2500/GU-84B is manufactured in the Svetlana factory in St. Petersburg, Russia.
GU-84b is the military version of the Svetlana tetrodes.Typical use would be transmitters "PLAMYA" ("FLAME"-eng.),used on submarines.In emergency mode GU-84B can work without cooling aproximately 20-30 minutes.Many amateur radio stations see 4 KW in SSB and CW modes. They use GU-84B in long-lasting contests.

CHARACTERISTICS:
Intermodulation distortion of the 3rd order - minus 35 dB
Anode Dissipation - 2.5 kW
Screen Dissipation - 30 W
Grid Dissipation - 1 W
Frequency for Max. Ratings- 250 MHz
Cathode... Oxide coated Heater voltage - 27 V
Heater current - 3.7A
Transconductance at Ua= 1.5 kV Ug2 = 375 V Ia = 2 A -->75 mA/V
Capacitance Input /Output /Feed-through / -115 pF /23 pF/0.2 pF --> Max
Seal and Envelope Temperature -200° C
Maximum Length -115 mm Maximum Diameter -99 mm
Weight-1.4 k g
Operating Position -Any
Blower -120 m3/h

The GU-84B tetrode is used for power amplification in traveling-wave and single-sideband signal amplifier circuits and as power amplifiers in RF equipment. GENERAL

Cathode: indirectly heated, oxide-coated.
Envelope: metal ceramic.
Cooling: forced air.

Height: at most 112 mm.
Diameter: at most 99 mm.
Mass: at most 1.3 kg.
OPERATING ENVIRONMENTAL CONDITIONS Vibration loads: frequencies, Hz 1-80
acceleration, m/ s 2 49
Multiple impacts with acceleration, m/ s 2 147
Ambient temperature, °C -10 to+ 70
Relative humidity at up to +35 °C, 98%
BASIC DATA Electrical Parameters
Heater voltage, V 27
Heater current, A 3.4-4.0
Negative bias voltage (at anode voltage 750 V, grid 2 voltage 375 V, anode current 2000 mA), absolute value, V 10-50
Grid 1 cutoff voltage (at anode voltage 2000 Volts grid 2 voltage 375 V, anode current 20 mA, anode resistance 0.5 k absolute value, V, at most 150
Zero anode current (at anode voltage 250 V, grid 2 voltage 375 V, grid 1 voltage 0), A 3.5-6
Grid 1 reverse current (at anode voltage 1000 V,
grid 2 voltage 375 V, anode current 2000 mA) µ A, at most 80
Grid 2 current (at anode voltage 750 V, grid 2 voltage 375 V, anode current 2000 mA), mA -25 to +60
Mutual conductance (at anode voltage 750 V, grid 2 voltage 375 V, anode current 2000 mA), mA/ V 44-72
Output power under conditions of class AB, at frequencies 0.1-1 MHz (at anode voltage 2000 V, grid 2 voltage 375 V, grid 2 current at least 80 mA, absolute value), kW, at least 1.5
Output power under conditions of class B at frequency 250 MHz (at anode voltage 2000 V, grid 2 voltage 375 V,
anode current 1500 mA, grid 2 current at least 60mA,
grid 1 current at most 4mA), kW, at most 1.2
Interelectrode capacitance, pF: input 90-115 output 18-23 transfer, at most 0.2
Limit Operating Values

Heater voltage (AC or DC), V 25.6-28.4
Anode voltage, kV: DC 2.2KV min to 4.2 KVmax A good working voltage for this tube is 3000v to 4000v
Grid 2 voltage (DC) V 400
Negative grid 1 voltage (DC), absolute value, V 150
Input voltage (amplitude value), V 150
Cathode-heater voltage (either polarity, absolute value), V 100
Cathode current, A: DC
component 2 instantaneous value 6

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2 TUBE GU-84B HOMEBREW 8KW+ OUTPUT HF I5UXJ

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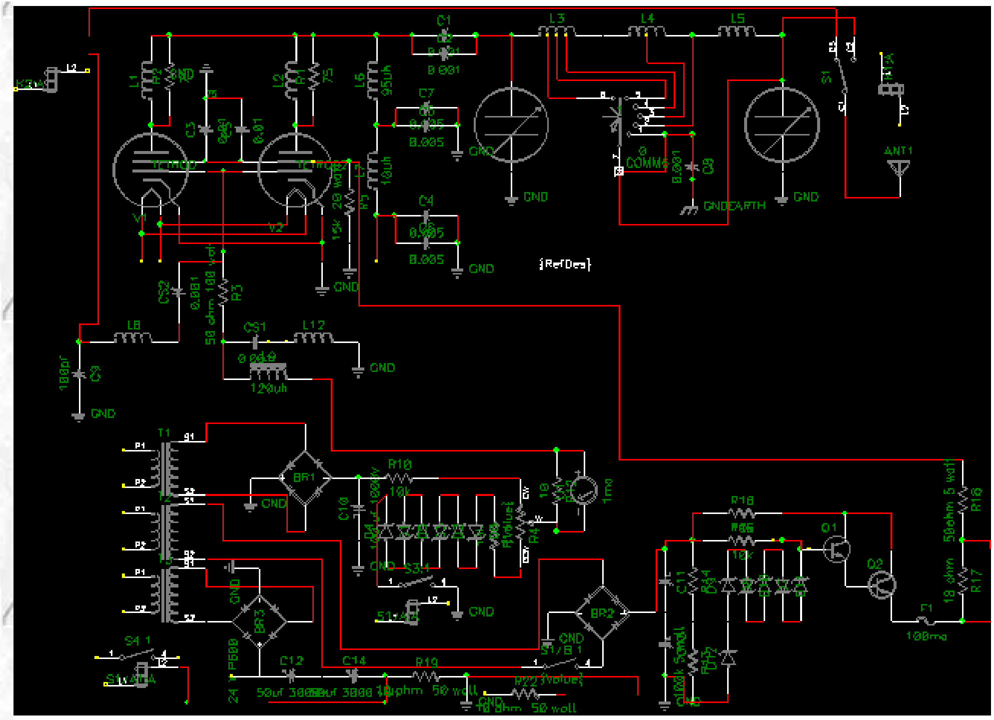
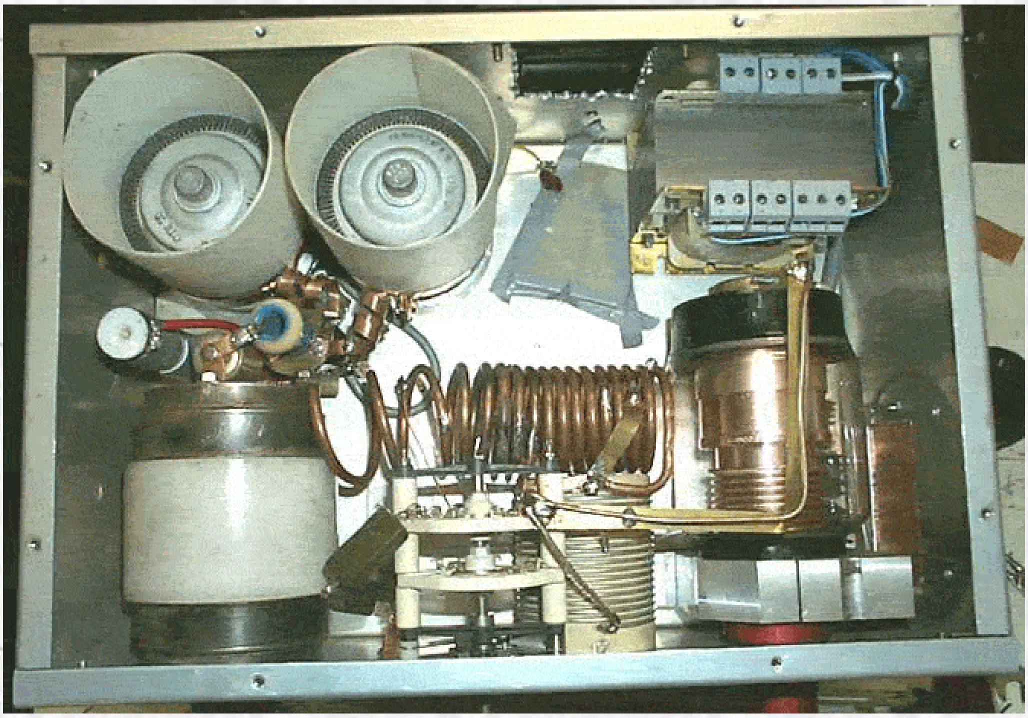
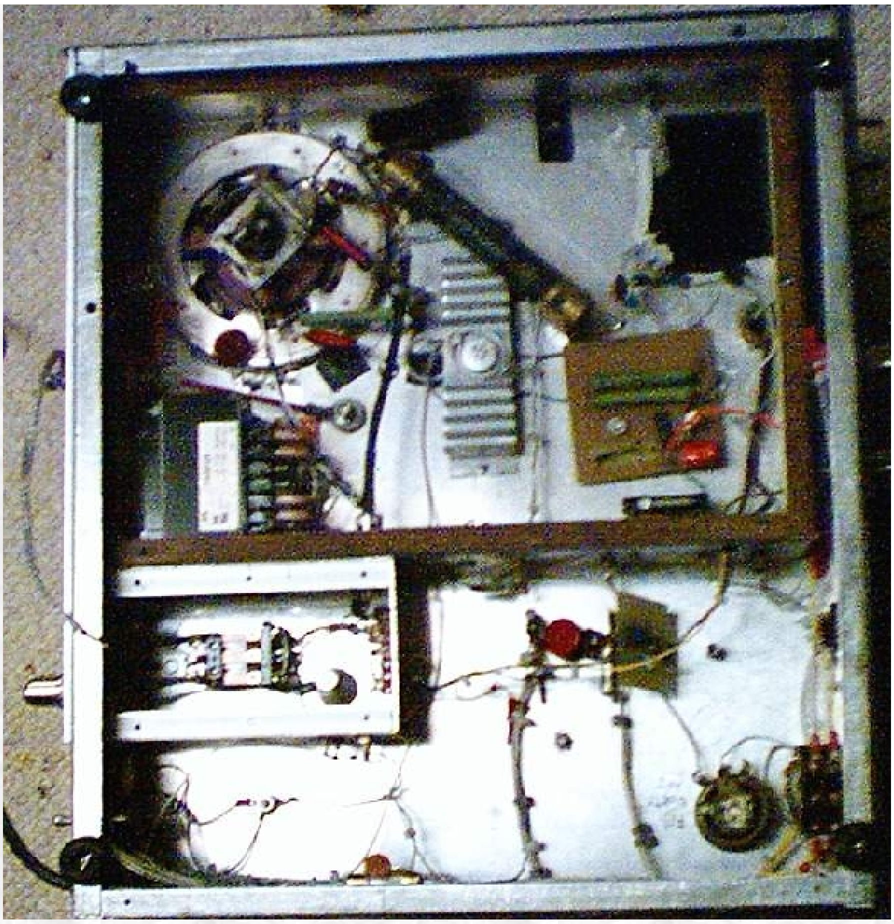
2 Tube GU-84B Schematic



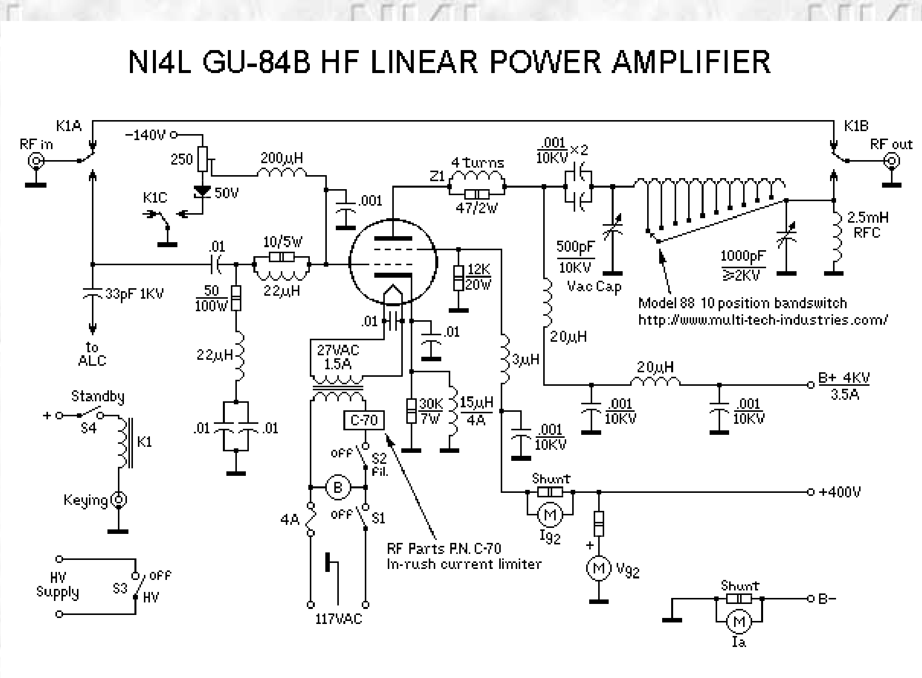


GU-84B 2 Tubes

NO9Z Bottom of RF deck 1 Tube GU-84B

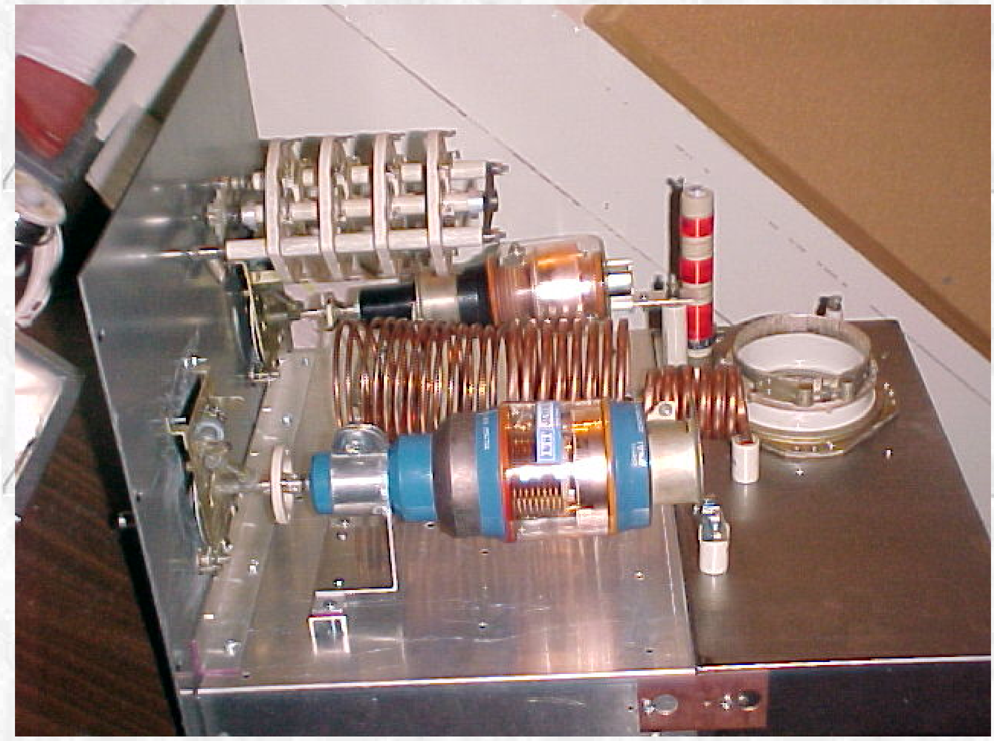


1 TUBE GU-84B HOMEBREW 4KW OUTPUT HF

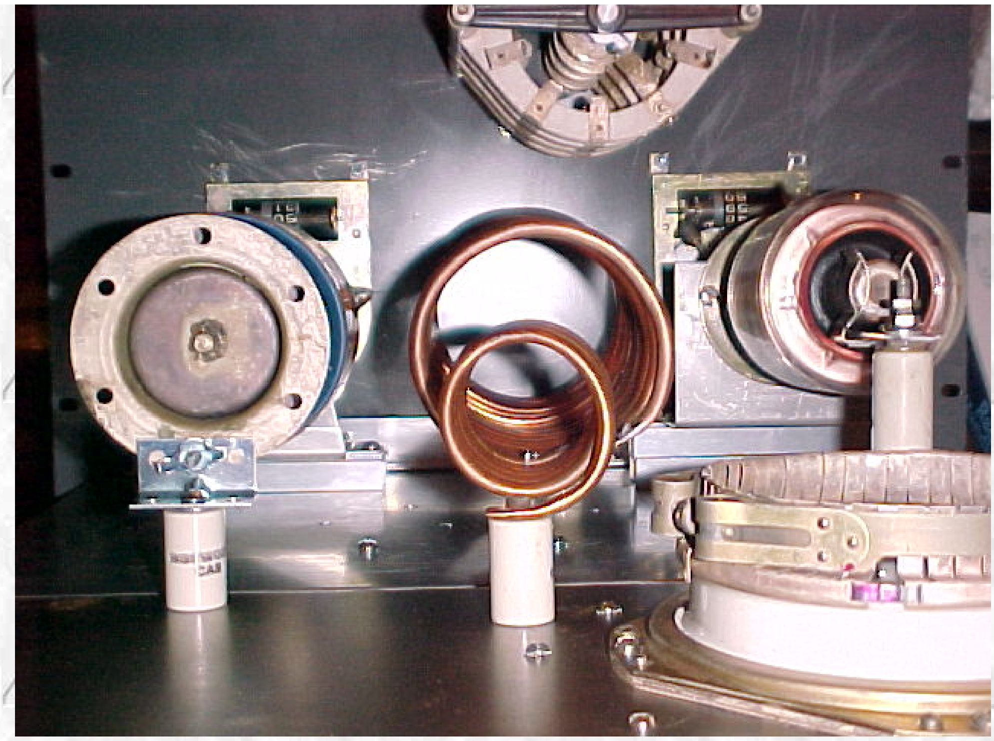


NI4L Front of RF Deck GU-84B

NI4L RF DECK TOP



NI4L RF DECK



NI4L CABINET

This is an on going project,More pics and info will be added as i have time.
I want to thank all of the gentlemen on the Amps@contesting.com Newsgroup for all the helpful insight they have given me on this project.And my good friend David KA4VNG for his help in ALL my Crazy endevors.. Thanks David.

Taylorsville, North Carolina
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NI4L ANTENNAS AND MORE

NI4L
NI4L RESONANT DIPOLES
RADIO / AMP REPAIR
SSB TUNING PULSER
QRO AMPLIFIERS
Russian components for amplifiers for sale
GU-84B Tube Specs
RF PARTS
144 MHz 1.5 kW GU-84b linear amplifier
Tony Welsh Russian Amp Parts etc.
TOM'S TUBES
Pavel Pop Good Parts Source
Surplus Sales of Nebraska
Military & Industrial Surplus Electronics
THE GATEWAY TO AMATEUR RADIO
Richard L. Measures, AG6K
MGS Great Parts Source
I 5 U X J - 2 QRO

032848

Email: ni4l@msn.com

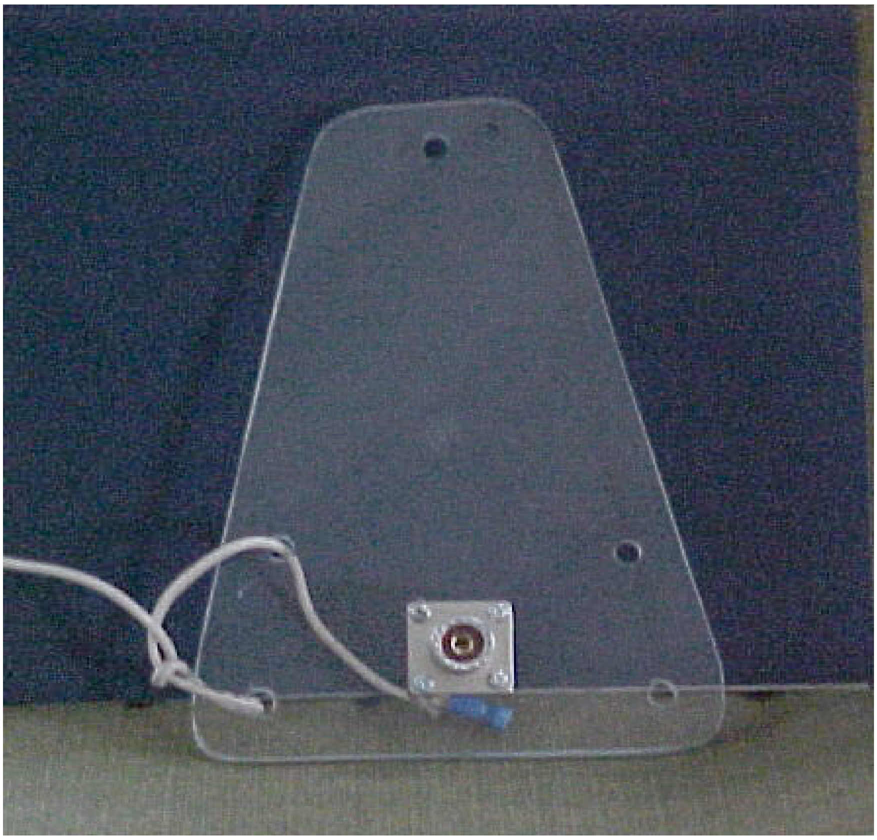
I took the tests... all of them... at a hamfest 10-11-08 in Pineville, a 3 hr drive, early on a Saturday morning. My wife drove while I reviewed study guides.

I passed 35/35 on the Tech, 33/35 on the General, and barely eeked by 38/50 on the Extra. Well, I passed! And I cheated... I'm not new to electronics. I've been playing with soldering irons since I was about 8 yrs old. I didn't start from scratch on this, just had to learn regs and such.

Enough of that!

I had gotten the Icom IC-R75 shortwave receiver early last spring and did what all newbies do. I stretched out a spool of hookup wire for a makeshift "random wire" antenna. Performance was so-so. I sought the advice of a friend from church who is a ham. He advised me to build an 80 meters dipole, and for SWL only, it would do well. He said, "Don't buy nuthinâ€™. We (the ham club) are going to fix you up."

One ham club member cut the dipole center and end insulators from 1/4" plexiglass (seen below), mounted an SO-239 socket in the middle, holes for the wire to tie onto, and at the top to tie to a rope. Another gave me some RG-8/U and a box of assorted fittings, and connectors. I had to buy only the mast and brackets, rope, and some 14 ga insulated wire.

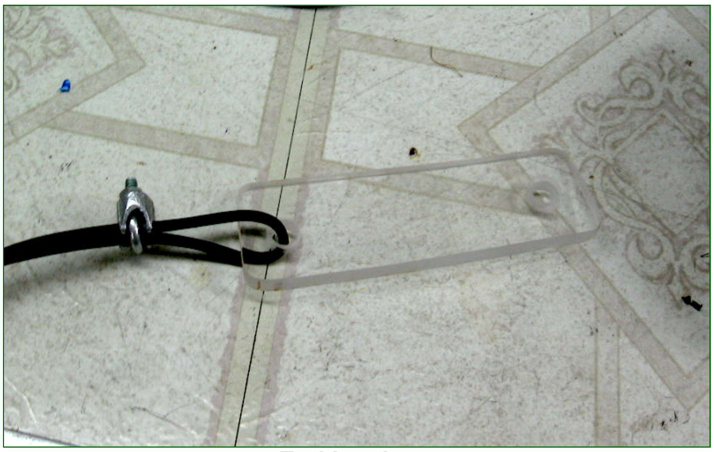


Center Insulator with S0-239

Center Insulator with SO-239 mounted and both sides soldered.
(See alternate center insulator using commercial insulator at bottom of article)

I use a lot of heat shrink tubing . . . I love the stuff. You can see in the picture above how I passed the wire end through the hole of the hanger, wrapped around itself 5 times, then heat shrink slipped over and shrunk in place to keep it from unwinding. Then the wire end was doubled back over the wraps toward the center, and another piece of heat shrink slipped over and shrunk, securing it in place.

The ends tie to 6" plexi insulators seen below,



End Insulator

The mast is mounted to a wood privacy fence on the side of my lot. I used regular TV type standoff brackets, with two 10' sections of TV mast tubing. Through what was to be the top end, I packed the end of the tubing about 4" deep with epoxy putty to keep it from collapsing. I drilled through that and inserted a piece of 3/8" all thread rod. Put a nylon insert lock nut (aka "aircraft nut") on each side and snugged it up. The epoxy putty kept it from egging on the end of the tube, and the nuts keep it tight. Two more nuts held a little 2" marine type pulley in place. I used some good 3/8" woven synthetic rope to go up over the pulley, and down to tie to the top of the plexi center insulator section. I can raise and lower that when needed, for storms, repair, whatever.

Mast attached to fence

The ends of the ropes from the end insulators are tied off to eyebolts in the top rail of the wood fence shown in the picture below. I later replaced the white rope in the pictures with black "550 parachute cord" (aka paracord) as the black wire and black paracord are practically invisible against most backgrounds, showing only if you get under it viewing it against the blue sky.

Tie Off Eyebolt.

At first I had just the two 66' legs for SWL. Great all the way down to 100 khz for beacons (ahh, what great programming!) from 100-300 khz. The AM band comes in great. 160 meters is almost useless, but on rare occasions I pick up some hams on phone or CW. So, I got that all working well with the R75.

Raised

The guys at the ham club and Steve K9ZW, a ham friend in another state, kept asking when I was going to get a ham license. Steve had gotten me the great deal on the NIB R75 from one of his ham friends. Steveâ€™s a VE, too. And he has a popular ham blog that has quite a readership, reviews of new gear and other topical subjects.

http://k9zw.wordpress.com/

I had to take the original 80 meter dipole down temporarily due to Hurricanes Gustav and Ike. This seemed like a good time to make some needed modifications.

Extra legs were added to make this a multi band dipole similar to the one shown here on Hamuniverse.

The original legs were for 80 meters, each leg cut to 66' (+ 2' folded back for tuning). I cut those for 3.55 mhz, not realizing at the time that was down in CW territory, and phone was higher. I later trimmed those back to 60' each side for 3.90 mhz for the phone portion of the band.

40 meters segments were added, each leg cut to 33' (+ 2' folded back for tuning).

20 meters segments were added, each leg cut to 16.5' (+ 1' folded back for tuning).

All connections were soldered and well insulated with heat shrink tubing and sealed with Scotch Linerless Rubber Splice Tape 130C 3/4" wide. This is the butyl rubber type tape that is soft and moldable, and commonly used for this purpose. Now the modified dipole looked like this:

Already I could tell that reception was better with the R75 on the 40 meter and 20 meter bands.

Due to the emergency situation created by Hurricane Gustav, I decided I really needed to go on and get a ham license which you read about earlier. Steve sent me one of his "spare field radios", a Yaesu FT-897, complete with installed FP-30 110 vac power supply and LDG AT-897 tuner screwed on the side. It was a complete package except for an antenna.

I had already modified my SWL dipole for three bands, adding to the original 60' legs for 80 meters, a pair of 33' legs for 40 meters (which work for 15 meters, too), and 16.5' legs for 20 meters. I did not know at that time about the correction factors that make tuning faster in an update to the multiband antenna article here, or would have done it as suggested.

Wide view of multiband dipole, choke assembly and J Pole on top.

A few more notes:

I used plenty of "coax seal" (Scotch 130C) around the plugs/sockets of both antennas.

I also added an "Ugly Balun" consisting of 17 turns of LMR-200 wrapped around a piece of 4" PVC pipe.

**Antenna shown with "Ugly Balun" and J Pole on top.
Notice the pulley arrangement.**

I had just gotten in some LMR-200. I ordered that as it is low loss coax, but is the same diameter as RG-58, to more easily wind a choke balun, aka "Ugly Balun", 17 turns on a piece of 4" pvc pipe. Home Depot sells little cut off pieces of PVC pipe so you don't have to buy 10' or anything like that. The wraps were held in place with Ty-Wraps through holes drilled in the pvc.

Steve wrote this about me...

http://k9zw.wordpress.com/2008/10/11/with-words-of-encouragement-newly-minted-ham-extra-class/

While at the hamfest I bought a B-Square Engineering 2m/70cm J-pole. It is stainless steel construction. Man, as much as I like DIY, I wouldn't fire up my torch to solder copper tubing at the price of the B-Square J-pole... just $40 in 2008 prices. While the antenna was lowered to add the balun I decided to take the mast down and attach the J-pole at the same time.

The J-pole is attached to the top of the mast with two stainless radiator hose clamps. The RG-8/U I had previously attached to the dipole was moved over to the 2m antenna. OK, it is a little lossy at 70 cm, and not great at 2m, but better than the LMR-200 at that frequency.

The LMR-200 is one continuous piece from the dipole center, around the pvc of the choke balun, and on down into my workshop/hamshack.

The wood fence is 143' long, the eyebolts for the longest segments are about 2' from each end, and parachute cord tied from eyebolts to the end insulators. So that makes for a very shallow inverted Vee.

The other two segments, 40 m and 20 m legs are tied to eyebolts further in toward the center mast, and form slightly sharper inverted Vees.

80m 40m 20m Legs

The white rope on the ends of the dipole elements in the photos has been replaced with black 550 parachute cord. The black is nearly invisible against most backgrounds. This is something to keep in mind if you have HOA Nazis lurking.

End view

The droop in the wires looks bad from an end view above, but it is really not that bad. You just cannot pull the wire tight enough to get it perfectly straight. There is a huge difference in pull between almost straight and a little sag. Don't try to pull it straight. Just get it acceptable. There will be a lot less strain and less likely to break in windy conditions.

Not mentioned before, GROUND. That metal building (my shop/ham shack) is on blocks on footings, and tied down on each corner to 6' long auger type anchors screwed into the ground. With the moist soil conditions here on the coast, and the large amount of area of the auger end of the anchors, they make good grounds. So my metal building is grounded on each corner, and I have additional ground wires from my transceiver and antenna tied to the nearest anchor as well.

There are lots of other ways to do this.
So get busy, and have some real fun like I did, with the multiband dipole!
==

So, how does it work?

I was listed in the FCC ULS database late Thursday afternoon of 10-16-08. Friday morning (I work 14 on/14 off), I checked out everything one last time, no shorts in the coax. I plugged it all up, read the manual again. I turned power down to 5 w, found a freq that was not being used just below 3.900 mhz, listened for a few minutes, then keyed the mic, gave my call sign and asked if the frequency was in use, listened some more. Then I announced I would be doing a short antenna test. (OK, most hams donâ€™t seem to do all that, they just tune. But it seemed the polite thing to do, and being a new ham, it couldnâ€™t hurt.) I switched to FM, keyed the mic with the meter set to read SWR. Not bad, about 2:1, and no magic smoke came out of the radio. Hit the tune button on the tuner and it dropped down to 1.1:1. Wow! And that tuner is noisy... sounded like my printer that just went out.

OK, that band will tune.

I changed bands up to 40 meters, found a freq around 7.2 mhz, same procedure, listened, gave my call, etc. With the tuner bypassed SWR was a little higher, but it tuned right up.

20 meters, SWR started out at at 1.5:1 and went down from there as it tuned.

I was able to tune 17 m, 15 m, 12 m, 10 m, and 6 m.

2 meters with the J-pole:
The tuner only tunes the HF bands, not the VHF/UHF bands. But 2m SWR was 1.1:1. Thatâ€™s good enough for me. 70 cm is a little high at 2.5:1, but it may be the extra 10' of coax coiled up inside the shop. Later Iâ€™ll cut off the excess and see how it does.

So, there you have it, two antennas, and the FT-897 with LDG AT-897 tuner that will cover from 80 m - 70 cm.

So, how does it really work?

The next morning, around 09:00, I made my very first QSO with my good friend and Elmer, Steve K9ZW way up in Wisconsin from my home in southern Louisiana, a distance of 1,016 miles, on 20 meters with that dipole and 100 w.

http://k9zw.wordpress.com/2008/10/24/working-paul-ae5ju-for-his-first-hf-qso/

Later I worked guys all over Louisiana and a guy in Florida on 80 meters. I also worked a guy in Massachusetts on 17 meters. He was pegging my meter, and me his. I mean PEGGED. Like you could hear the needle click on the stop pegged.

I also signed in on a net up in New Iberia (just south of Lafayette) 45 miles away on 2 meters with just 8 watts with that B-Square Engineering J-pole.

So far no luck on 6 meters or 10 meters. Just no activity up there at this time, but those bands will tune up.

Final Lengths and Testing Updates 11-16-08

I spent the afternoon checking SWR at several places on each band, trimming length.

Here's what I started with:

120' total (60' each leg) for 75 meters

66' total (33' each leg) for 40 meters

33' total (16.5' each leg) for 20 meters

----

75 meters 60' each leg

SWR @ 60' 3.665mhz = 1.1
3.800mhz = 1.9
3.995mhz = 5

This showed that it was too long, resonance down around the lower end of the phone band. I wanted to get that higher, nearer to 3.9 mhz. I took 26" off each end = 57.83' each leg

SWR @ 57.83' 3.665mhz = 2.6
3.780mhz = 1.3
3.850mhz = 1.1
3.995mhz = 1.2

This is VERY close to the 96% adjustment for the lowest band segments from the Multiband Dipole page at HamUniverse.com.

---

40 meters 33' each leg

SWR @ 33' 7.165mhz = 2.0
7.218mhz = 2.4
7.290mhz = 3.0

I took 8" off each end = 32.33' each leg

SWR @ 32.33' 7.165mhz = 1.1
7.225mhz = 1.1
7.292mhz = 1.3

Again, this ended up VERY close to corrections from the Hamuniverse page. I could probably have taken off another 1/2" or so, gotten the upper end down a fraction, but why? That is close enough for me.

---

20 meters 16.5' each leg

SWR @ 16.5' 14.155mhz = 1.2
14.275mhz = 1.3
4.345mhz = 1.6

It is easy to see this section was a little too long.

I took off 1" each end = 16.4' each leg

SWR @ 16.4' 14.155mhz = 1.4
14.175mhz = 1.3
14.190mhz = 1.1
14.275mhz = 1.1
14.345mhz = 1.1

I went back and confirmed that 75 meters and 40 meters were still the same as before, had not changed as a result of tuning the 40 m and 20 m legs.

After trimming 75m, 40m, 20m segments, these figures were obtained on higher bands.

17m 18.120mhz = 3.5
18.160mhz = 3.5

15m 21.205mhz = 3.0

12m 24.960mhz = 5.0

10m 29.000mhz = 2.0

6m 52.800mhz = 2.0

15 meters had been somewhat lower, around 1.2:1, before I tuned the 80m and 40m segments, but not too bad now. It is easy to see that shortening the 40 meters segments shifted the resonance for 15 meters up out of the band. But the tuner easily handles it. And 17 meters is about what it was before.

Additional notes:

All SWR readings above were obtained with the tuner bypassed, that is, the coax in from the antenna was plugged directly into the radioâ€™s HF antenna socket. These bands all tune down to 1.1 using the tuner.

I don't think I'm going to do any better than this. Everyone tells me to leave it alone now!

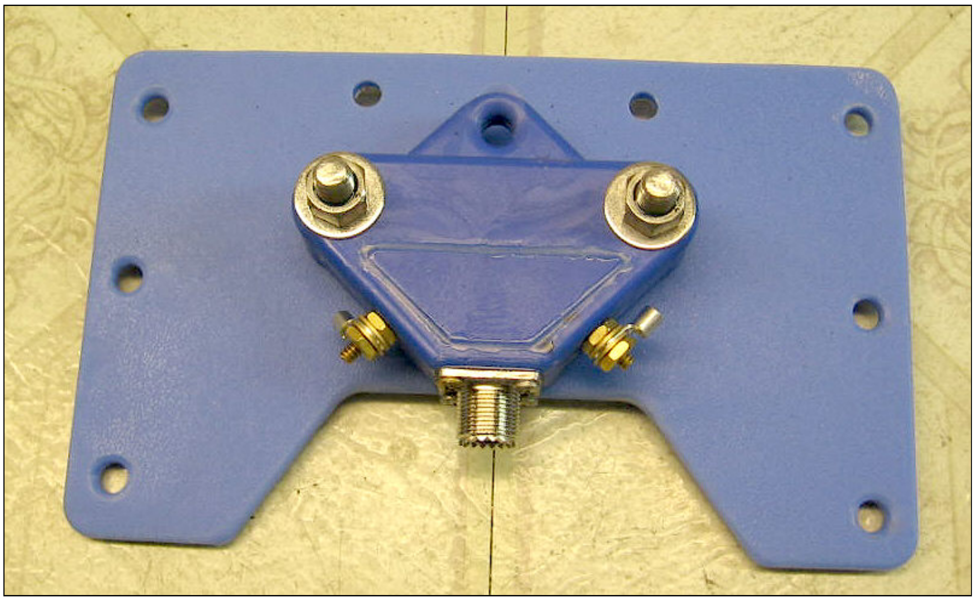
Had I used the Stanford Research corrections as per the [Hamuniverse Multiband Dipole] **page, I would have already been finished.**

Update - November, 2009 - ALTERNATE CENTER INSULATOR USING COMMERCIAL INSULATOR:

After the antenna had been up for a while, I fired up the radio to check in on the HiFivers Net and the antenna wouldn't tune. Impedance was very low. I found out the exposed side of the SO-239 connector (in the original construction article above), the center insulator on the dipole was dirty.
I had failed to use a "hood" to seal the exposed side. Other corrosion on the connector, too.

Water had gotten into the SO-239 socket also. I made a new center hanger by bolting a Jetstream JTCE1 Dipole Center Insulator to a piece of plastic kitchen cutting board. The holes for attachment of the wire legs were chamfered by lightly touching the holes with a larger diameter bit. The V shaped notch on bottom is to allow easier wrapping of the coax connection with Coax Seal or Scotch 130C butyl rubber tape.
I already had a new hanger fabricated from a Jetstream JTCE1 Dipole Center Insulator and a piece of plastic kitchen cutting board. See photos below:

Jetstream Dipole center insulator



Jetstream Center Insulator mounted on plactic cutting board backing

The notch on the bottom of the backing piece is to make it easier to wrap the coax connector with coax sealing tape (Scotch 130C).

It took only minutes to replace my original center insulator with this new, more weather resistant one.

73 Paul - AE5JU

Tune Around!
SEARCH

CQ-Calling All Hams!
About Hamuniverse
Antenna Design
Antenna Safety!
Ask Elmer
About Batteries
Code Practice
Computer Help
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The TAK-Tenna(TM) Review
A Limited Space HF Antenna Review

The TAK-tenna(TM)

by Don Butler, N4UJW
Hamuniverse.com

For immediate release to the ham radio public 03/01/10
TAK-tenna is now patented!
Patent number 7586462

(Note: This review was originally done in May, 2007 when the TAK-tenna first came out and has been updated since then)

Why am I doing this review? I don't review antennas! I don't recommend antennas!

As you may know, a big percentage of this web site is dedicated to building antennas and not buying them, but sometimes an antenna comes along that is so unique that it deserves my attention.....and yours!
If I normally did antenna reviews then I would probably get right into it but a bit of introduction is needed to help you understand why I am reviewing the TAK-tenna. Prepare for some reading. What's that? You just want the bottom line.....BUY IT!

The Space Problem and Murphy's Law!

Most of you have heard of "Murphy's Law"...you know...he is around when everything goes wrong that can go wrong.

Many hams just don't have the space to put up standard length HF half wave dipole antennas but would give their left arm to operate on the HF bands without being limited in one way or another due to space. Many hams are so restricted that HF antennas, due to their length on the lower bands, are almost totally out of the question. In lots of situations, even a simple half wave dipole on 40 meters just will not fit.....Murphy's law.

Yours truly is limited by the lack of natural supports for any kind of antenna due to being on a lot with absolutely no trees! So if an antenna that I have needs support, then I have to either build it or buy it. Mother Nature has not helped me in any way and the XYL hates guy wires and junk metal poles all over the place.

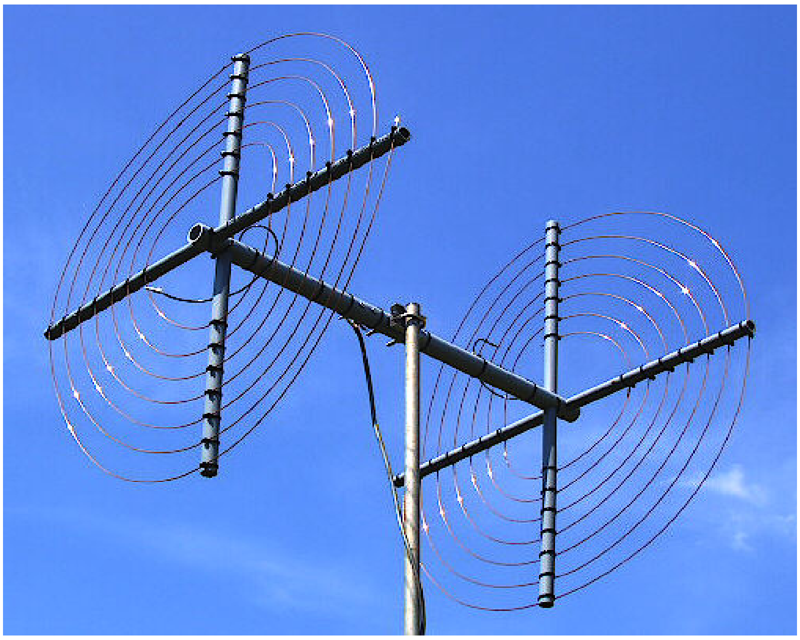
Hams like myself are limited by too many trees, not enough trees, antennas requiring various supports, property lines, overhead power lines, home owners association rules, layout problems with small city lots and on and on. If a ham can be restricted or limited with the antenna system layout for his HF antenna, then Murphy's Law will kick in and see that he will remain restricted in some way. I am certain Murphy has many twins and one of them has probably visited you at one time or another in your search for an HF antenna that will fit your space.

Can you imagine needing about 65 feet horizontal distance to put up a 40 meter horizontal wire dipole or inverted V and all the space you have is just enough BUT.....the neighbor's fence and that power line is in the way. Murphy just kicked you! So you look around and find another possible location....nope....the top of the house will be too close and there is no way to get around that tree! Murphy.....again! Climb the only available 50 foot tree....what...no safety harness......slingshot practice in the dark.... ....what was that sound.........glass breaking?......Murphy again.....How about that twig of a stick you call a tree......too short....shut up Murphy....what is a ham to do?

I get many emails from hams in similar situations wanting suggestions for limited or restricted space antennas for HF operation and in some cases, I have to do research on the web to come up with a good suggestion for a limited space antenna that is workable on HF. Of course, much depends on the particular layout of the QTH.

The problem with most HF antenna layouts is the lack of horizontal space and supports and in most cases going up is the only alternative but for one reason or another a vertical is out of the question with all those radials that you just don't have room for....Murphy again.....what is the answer? Well, maybe I have found an easy and inexpensive way to kick Murphy away from your limited "antenna farm" permanently!

The TAK-tenna Compact Concept!



NO....it is not a vertical nor one of those EH antennas!
It is an electrical half-wave dipole believe it or not!

I may have found one very usable antenna that should work in most locations unless your QTH is located in the dog house.....but you still may have room! Let me explain!

One day while searching the web for unusual antennas, I was introduced to a "new" concept, (to me), an electrical half-wave dipole based on what is called the Petlowany principal of spiraling a 1/4 wave length "pancake" of wire on each end of a greatly reduced boom length yielding an antenna that was very usable as far as size was concerned. What I saw was a 40 meter half wave dipole antenna compressed into such a small size that I thought it should work poorly or not at all.

Being the "I want to know" for the sake of knowing person that I am, I had to find out for myself whether this was a bunch of static or not.

I set out to experiment with it at 2 meters using this principle and it proved to me that it worked and worked well! This was truly a remarkable principle and I had proved to myself that it worked in such a tiny package!

Using the very poorly built wire antenna with junk box engineering and "make do with what you have" ingenuity using this Petlowany principal, gave me an antenna that hit repeaters 60 miles away from inside a single story house over flat terrain! At 2 meters it was made from a

broken yard stick as the boom, and a couple of pieces of cardboard, tape and some wire. It was straight out of hillbilly junk yard junction....but......this contraption actually worked! I was hitting 2 meter repeaters 60 miles away over flat terrain.......from inside the house!

Enter the TAK-tenna Company

Now the TAK-tenna company, using principles based on ideas by Petlowany and many others all the way back to the beginning of radio, using some major modifications, lots of engineering, mechanical and technical improvements, has developed a line of patent pending greatly reduced size HF antennas that may put regular length dipoles in their place where they belong....in non-restricted layouts!

A 40 meter electrical half wave dipole in a 30 inch space that performs?.......I will have to prove it to myself and you the reader with this review!

The TAK-tenna line of antennas are extremely reduced space antennas both horizontally and vertically yet remain electrical half wave dipoles. My idea for this review was to see if they worked as well as I had hoped they would, given the fact that thousands of hams are very limited with room for HF antennas and are constantly looking for better ways to get out a better or any signal on the HF bands while having limited or no space for dipoles. And all for the price of taking the family out to a good meal.....unbelievable!
We'll see.....

About the TAK-tenna review!

"Just to set the record straight, I am in no way affiliated or connected with the TAK-tenna company and owe them nothing in return for this review nor do they owe me anything. I will freely admit that they did supply me with an antenna for my review with no strings attached. No, it is not a tweaked and peaked version or their production model so it will pass my review with flying colors if some of you are skeptical....it is just like the one you would get in the box if you ordered it from TAK-tenna.

As a general rule, I do not endorse or do any ham radio related product reviews nor make recommendations. My sole purpose of reviewing this antenna is for the benefit of the viewers and readers of Hamuniverse.com and to satisfy my curiosity about this new antenna to help hams who may be looking for a restricted space HF antenna that

will help them get a better signal out on HF when they are limited with space.

I happen to enjoy helping other hams with their antenna limitations and questions and if I don't know the answer, I will do my best to find it for you as many of you have found by the emails you have sent me. If my review of this antenna turns out negative...then my advise for what it is worth would be..... don't buy it....but if it turns out positive in my opinion, then it would be well worth your consideration for a limited space hf antenna.

This review for the TAK-tenna may help you decide to try it....or not. It makes no difference to me but I do know that this "type" of antenna......WORKS and the principles behind it are sound and repeatable.....but a paper clip will radiate rf too....to some extent!
Let's see how this limited space antenna compares to a paper clip or wet noodle and my center fed multiband doublet and a ground mounted vertical that are not restricted....except by the XYL!.......but wait......that's not a fair comparison...or is it? N4UJW"

Background of the TAK-tenna company

The TAK-tenna antenna design is the brain child of Stephen Tetorka, WA2TAK, U.S.A.

The company name, TAK-tenna, LLC, was derived from part of his call sign.
"Steve, WA2TAK, has a Master's in Engineering...spent 25+ years in Engineering/Manufacturing...including several years with NASA. There's a 30% chance you are within an arms distance from one of his products --
he co-developed the special wire used to make the motor winding for Seagate Technology's hard disk drive that might be in the computer you are using right now.".....Source QRZ.COM - WA2TAK

The TAK-tenna Antenna:

This information below with the yellow background was taken directly from their web site and slightly edited for space on this page. None of the content from their web page has been re-worded. All of the pictures of the TAK-tenna below were taken during the tuning and operating phase of this review.

Electrical Half-wave Dipole Antenna

Electrical Quarter-wave radiating spiral end elements
Rotable Portable Stealth Perfect Backup Antenna

Direct feed with 50 ohm coax on resonant band
Can use coax + tuner...or twin lead + tuner - FB
Power tested to 1000 CW watts, key down for 30 seconds and 1400 Watts PEP...all FB.
NO lossy matching components anyplace in system
10 to 14 dB signal increase in transmit with 90 degree rotation
30 inch boom

Low SWR across band

Sturdy and well built
Weighs only 5 pounds
Uses proprietary #14 gauge copper plated alloy wire
Easy assembly about 45 minutes

(TAK-tenna during tuning phase for this review)

Tested, Proven and Endorsed by Collins Radio Association

TAK-tenna LLC, 154 Lexington Avenue, Fair Haven, New Jersey 07704
Telephone 732-530-8530
WA2TAK..(enter call sign on www.QRZ.com)....Email-stephentetorka@cs.com

Original Tak-tenna ad back in May, 2007 (Edited for space on this page)

The TAK-tennas are available in 3 models - 40, 20, and 10 meters.

The 40 meter model can be used on 40, 30, 20, 15, and 10 meters with a tuner.

Update 12-09

The TAK-Tenna is now available for 75/80 meters!

Quoted from Steve Tetorka, WA2TAK - TAK-tenna-

"If we have made a small contribution, it is because we stand on the shoulders of those who preceded us"......"spiral antennas goes back to early 1900's...the 'spider' which generally sat on top of the wood cabinet of those TRF AM broadcast radios......"

~~~~~~~~~~~~~~~~~~~~~~~~~

THE REVIEW

The model we evaluate is the 40 meter model due to the fact that it can be fed with either 50 ohm coax, for single band operation or you can use it with twinlead or coax and a tuner for the additional bands of 30, 20, 15, and 10 meters for a total of 5 HF bands. It comes in kit form as do the other models and at the present time, according to TAK-tenna, is the most popular because of this feature. Other models are in the research stage.

The 80/75 meter model is now available and other bands may be in the works!

My evaluation for this review will be based on a scale of 5 for each criteria with 5 being a perfect score for each criteria and I have attempted to choose the most important criteria that most hams will be looking for and also added a couple of my own so this review scoring system may not be what you were expecting and is the result of my opinion and my opinion only.

Now that you have been introduced to the TAK-tenna, let's get on with the review!

40 Meter Tak-tenna reviewed 11 feet off the ground!

(There will be a total of 20 review criteria listed below for a maximum possible point score of 100. You will see my comments after the score for each of the criteria and note that this review in no way is to be considered a computer model simulation or results from an antenna test range....this review is just my observations, and end user thoughts and comments from a regular ham like yourself.) I have attempted to do this review with the ham in mind that has limited space for HF antennas!

THE SCORES!

1. The most important criteria of my review will be the on the air performance!
(5) If I could give it a 10, I would!
I can confirm that I had so much fun with this antenna on the air that I almost forgot about doing this review! It is a remarkable antenna for it's size! Nearly all of the contacts I made were 5 9 reports during less than favorable band conditions using an old Yaesu FT 107, 100 watts, SSB on

40, 20, and 17 meters...Yes 17 meters too! Cuba was loud and clear giving me a 59 report....and the TAK-tenna was only 11 feet off the ground during all of the on the air testing. I can not stress enough the fun I had reviewing this antenna on the air!
And as an added note, no one on the other side of any conversation over the air knew what antenna I was running. I only said that I was using a 40 meter dipole up 11 feet and the QTH was Texas, near Dallas.

Other considerations:
2. Clear and easy to understand instructions? (4.5)

I followed the instructions exactly as written in the manual in the order that they were written and did not jump around between steps.
The instruction manual contains good quality pictures and drawings that are very helpful but some of you less experienced builders may like to see a drawing of the completed antenna with part descripions, and their locations with reference numbers....especially concerning the way the support tubes attach to the boom with nylon ties as noted below. Even one drawing or picture of the support tube/boom junction point would have been helpful to some builders.

Most of the instructions were very clear indeed, however when attaching the supports to the boom, I did notice that there were holes drilled in the center of each support arm when I took them out of the box. There was no mention of why they were there in the instructions. With a bit of further investigation and logic, I determined that they are there so you can use them to feed the nylon ties into the holes and around the boom so the support arms can be securely attached to the boom. The support arms are not bolted to the boom but using the nylon ties in the proper manner makes for a very sturdy setup!

One other very minor thing, (to me), was the fact that you are instructed to cut a 26 inch length of wire from the supplied length in the kit to use as a connecting wire from one side of the feed connection to one of the spirals, with no mention about the left over wire or where it goes. Very shortly, using simple logic, there is only one option. It has to go to the other spiral. This could be slightly confusing to a non-experienced antenna builder. I pretended I was that person!

Other than this, instructions were excellent!

3. Ease of assembly, any missing parts, assembly time required? (4.5)

This score should probably be a 5 but due to the fact that it took me about 1 hour and 15 minutes from unpacking to final completion during the assembly portion, I decided that the "about 45 minutes" statement on their web site should be lengthened a bit.

UPDATE: The Tak-tenna website now states "Easy assembly - less than 90 minutes" rather than the original "45 minutes" back in May, 2007.
I realize that this may be a bit picky but this is the way I see it. Guess this is a play on words on my part and it would all depend on many variables with individual builders. I in no way mean this to be understood as false advertising!
I did take my time to "get it right" the first time.

I also must admit that the very novel method of attaching each spiral to the support tubing using notches and nylon ties on the tubing is an excellent idea. I am commiting that one to memory for future home brew projects! If I had included just this one simple idea as another review criteria, it would have gotten a 10! Great idea Steve!

4. Any special tools or test equipment required for assembly or tuning?(5)

By following the instructions which were well written, all you really need is just a standard HF swr meter and an hf radio capable of 40 meter operation, a tuner if multiband operation is desired, 50 ohm coax or twinlead, measuring tape, screw driver, soldering GUN, solder, wire cutters and a tool to tighten the mast clamp to the mast or your own preferences for tools. The average ham should already have these.

5. Can the TAK-tenna be put on the air with acceptable performance using a tuner without tuning the antenna for lowest swr during the "tuning" portion of the instructions by just following the instructions like some other commercial antennas on the market? (5)

You can almost call this antenna PLUG AND PLAY! Winding the spiral coils onto the supports could be a bit tricky for some builders, but the instructions are VERY clear on the procedure. Just take your time. I found this very easy. Simple tips are given in the instruction manual for winding and as I mentioned above, the novel idea of the notches in the support arms for the spirals make winding a simple process.

By using the "starting tap points" suggested in the

instruction manual, the swr was about 2 to 1 using an MFJ 259B antenna analyzer on the 40 meter band down near the lower portion of the band. This swr should pose no problem for a tuner using the initial starting tap points. Please not though that due to your individual construction practices, the initial swr reading may different for you.

6. Any special or unreasonable restrictions on location, mounting or height above ground? (5) SEE UPDATE AS OF 11-30-08 BELOW!
I installed it for the original review at 11 feet from the ground exactly at the boom and it tuned as expected using the instructions. Why did I use 11 feet? This is the length of an old CB vertical section I had laying out in my "junk pile" as my XYL calls it, of aluminum tubing. As you builders out there know, we call it "gold".
I have not attempted to operate it lower than the 11 feet in the original testing in May, 2007. There are reports that it "works" below this limit and I have confirmed them in the update below!
UPDATE (11-30-08) I have confirmed that...the TAK-tenna has been operated as low as 2 feet above ground - on a camera triopod - in vertical propagation orientation...and as low as 5 feet above ground in horiztonal propagation orientation so this would certainly add to it's versatility!

7. How does it perform at extremely reduced heights? (5)

I have not personally tried the Tak-tenna at other than 11 feet but according to the many other reports I have read, it performs well down to 2 feet above ground in the vertical orientation.
I have not used it at any height below the 11 feet height above ground in the testing. Others have reported good results down to 2 feet as in #6 above.
So to be fair with this review, I gave it a 5.

8. Does it require more than one person to assemble and mount? (5)

Unless you are severely disabled, you should not have any problem with any part of the assembly or mounting. This antenna is so light, 5lbs, that it is indeed very easy to assemble and get in the air by one person!

9. Was it easy to tune for lowest SWR? (4.5)

I don't know of many, if any, commercial or homebrew antennas that are perfect when it comes to tuning. There is NO cutting or trimming of this antenna required or suggested to get a good low swr. I was able to

get it down to about 1.5 to 1 swr by some expected trial and error by following the instructions using the alligator clips supplied for initial tuning of the tap points on each spiral. Don't get discouraged, it is very tunable for low swr on 40 meters! Do not expect low swr on any other band other than the resonant band of 40 meters.
Remember, this is an electrical half wave antenna. I did note that the swr was usable on 15 meters as would be expected unless you are a perfectionist. As the manual states, there may be rf on the shield so follow the instructions and suggestions supplied in the manual and don't let this fact worry you....the antenna will perform!

10. Was the SWR low over a good usable range as determined by the MFJ259B as a test meter? (4.5)

YES! I suspected at the beginning of the review that after final tuning during the initial setup that the TAK-tenna may be very narrow banded on some bands. However, when using a tuner, and 50 ohm coax feed, at 11 feet off the ground, I found that the usable range on most bands was very adequate without having to retouch the tuner adjustments. 10 meters was a bit tricky with an MFJ 901B tuner, but with some very fine tuning of the controls, it fell right into 1 to 1 swr at 28.400mhz!

And for you "Techies" out there, the MFJ 259B showed me a match efficiency of 99% at 7.1668mhz with an swr of 1:1 and at 21.590mhz, 98% with a 1.2 to 1 swr at the shack end of the coax if you put much faith in the very popular MFJ antenna analyzer.

11. Mechanical stability and material quality? (5)

EXCELLENT!
The TAK-tenna company uses high quality materials throughout. I did not find any problem with the construction quality of anything supplied with it.
(The alligator clips supplied for tuning only could be a bit larger for bigger fingers!)
There is extra spiral wire included and plenty of black uv type nylon ties. Don't worry if you make a mistake during construction and wonder if you have enough wire and ties to complete the job....you will! You might even have enough of the spiral wire for a 2 meter ground plane or vertical dipole! I saved mine for a later date!

12. How the TAK-tenna compares on the air to an 80 meter homebrew multiband center fed doublet dipole fed with TV twinlead using a tuner up about 30 feet set up in a North to South configuration? (5)

I could not give this test comparison a fair un-scientific test due to band conditions except on receive, and could not get a steady signal with any antenna I had for a good comparison but one thing I quickly noticed during switching between TAK-tenna and the other dipole I had was the fact that I HEARD no noticeable difference on any band. I found this remarkable compared with about 123 feet of wire up about 30 feet! The on the air tests in #1 above proved to me how well this antenna works for it's size.

13. How does it compare to a ground mounted multiband commercial Hustler 4BTV vertical with no radials and fed with RG58 coax? (5)

Again, I HEARD no noticeable difference except that foreign broadcast did seem to be just a bit "louder" on the 4BTV and the S meter confirmed less than 1 S unit difference if you can put much faith in S meters. I am sure that this could be due to the angle of radiation of the vertical being lower than the TAK-tenna, but in any case, 21 feet of commercial antenna compared to 30 inches.....you be the judge!

I am even considering using the 4BTV Hustler vertical as an expensive 21 foot mast for mounting the TAK-tenna on top of it in the future!......But then there is Murphy's law and the XYL stepping in....I may have to use some guy ropes! The XYL hates guy ropes and wires! Go away Murphy!

14. If used with a rotor, can it help to "null" out stations in undesired locations? (5)

This was a test of the TAK-tenna I conjured up using the characteristics of a "rotatable dipole" compared to the TAK-tenna and is not, in my opinion, a fair test due to the fact that TAK-tenna makes no references to the fact that it can "null" out stations off the side.
The TAK-tenna web site states "10 to 14 dB signal increase in transmit with 90 degree rotation". This tells me that if the TAK-tenna is rotated toward a station under controlled conditions, (a good steady signal), and an S meter reading is taken, then if the TAK-tenna is rotated 90 degrees, the signal should drop about 10 to 14 dB.
I am putting words into this that TAK-tenna does not state. They make no statements to the effect that this antenna is directional, but in my opinion, if it acts like a dipole that ordinarily has worst performance off the ends, then this, in my opinion, is what we are seeing here.
If you look at the design of the TAK-tenna from an angle of 90 degrees to the boom, you see only a very tiny amount

of wire "exposed" in the direction of a station 90 degrees off the side vs "looking" at that same station "head on". The TAK-tenna is not a Yagi, and in no way does the company refer to it as such, so don't expect that sort of performance from it!
This is a very, very compact electrical half wave length dipole antenna,
no more, no less!

15. Cost versus time saved dealing with MURPHY'S LAW? (5)

EXCELLENT!
If you could build this antenna from "scratch" as a complete home brew project, then I believe Murphy's Law would win! I honestly do not think you would save ANY time nor could you save ANY money by attempting any other method other than ordering one of these antennas from the TAK-tenna company. Just cutting the notches alone for the spiral wire would take a long time plus all the drilling of the other holes required for the boom and spiral supports. For the price of this antenna at the time of this review, how could you loose and still get out a good signal on HF with your limited space?

16. Is the TAK-tenna advertising on their web page misleading in any way in my opinion? (5)

Absolutely NOT!
I could not find one statement on their site that could be considered in my opinion as misleading in any way.
They do not represent this antenna to be a "miracle" antenna in any form. They do not represent the TAK-tenna as bending the laws of Physics or changing them in any way.
It is designed mainly to be used in limited space situations for hams who are restricted to little or no HF operation due to lack of adequate antenna space among it's many credits.

17. Was it shipped in an adequate container to prevent shipping damage? (5)

YES! The antenna was extremely well packaged in a sturdy container and survived the rigors of going through the many hands of Federal Express!

18. If I decide to take it down and use it at another location like camping or field day, will I have problems with the disassembly and reassembly?(4)
This may not be a fair test but I threw it in anyway!

This model for this review, the 40 meter version, is only about 30 inches by 30 inches assembled and extremely light in weight. In my way of thinking, it could be taken off the mast and just put it in the back seat of most cars. The spiral wires are very stiff but could of course be bent somewhat out of shape with ruff handling.
One recommendation I might have would be that if you foresee moving it many times to different locations like camping or field days, would be to simply modify the boom on each side by cutting in the center of each side and adding a coupler of some sort using short bolts thru the boom while keeping the same boom length of 30 inches. Then it should be just a simple matter of taking the antenna apart leaving two "pancake spirals" and the mast portion of the boom left to lay flat. Use your imagination. TAK-tenna makes no references to this one way or the other.

19. If for some reason the antenna breaks at some future time, can I easily repair it myself without having to re-order high priced parts for it?(5)

I am going to really stick my neck out here for the TAK-tenna company to chop off and say yes. I did not design the antenna but from outward appearances, there is nothing in it that you could not replace using materials from Home Depot, Lowes, the hardware store, etc to get it back into operation. Hopefully there are no reasons why you could not do this. In my opinion, when antenna companies use special materials, components, parts and pieces for their product with the express purpose of making their products non-repairable except when using only their inflated high priced replacement parts...then they are only in business for one thing...and it is not you and
I realize also that with many commercial antennas, there are many machined parts that require special equipment to make....most hams don't have a production line setup.
I see nothing in the TAK-tenna that would require more than everyday hand tools to get it back on the air.
I do not get the impression about the TAK-tenna company concerning the importance of money over the end user. I believe they are in business for the ham radio operator and not against him. This antenna could easily sell for $100.00 or more and they should sell like hot cakes at that price but as of this writing, the TAK-tenna is no where near that price!

Sure, they should make a mint with the TAK-tenna.....I wish them all the best!
The most fragile part of the TAK-tenna is the spiral wire used on each end. It should not break under normal uses

so I really should not call it fragile. This is proprietary #14 gauge copper plated alloy wire and I assume it is made specifically for this antenna. I am sure that if you feel better about replacing anything on the antenna, the company will be happy to help.

20. How did it perform as a multibander? (5)

EXCELLENT!

This TAK-tenna antenna really shines as a multibander! You will forget how small it is while operating!
I can confirm that this antenna should perform well for you on it's advertised bands with a tuner and I found that 40, 30, 20, 17, 15, 12 and 10 meters "tuned" just fine for me giving a bonus of 7 HF bands in such a small space! Your tuner may be different than mine so you may not get this performance...experiment!
I used a very basic MFJ 901B tuner during this review and if it will "tune" this antenna with no problems, then your tuner should too.
Like I said at the start of this review, I was having so much fun with this antenna that I almost forgot this was a review!

I made several contacts on 40, 20, and 17 meters using 100 watts ssb or less with no report less than an S9 or a 59 report under terrible band conditions, summer static and at various times of the day. A Cuban station reported 59 copy on 17 meters. 15, and 10 meters were "dead" during the initial on the air testing. I did not do on the air testing on 30 meters but receive was fine. I see no reason why 30, 15 and 10 meters should not do well with average band conditions and due to the fact that I wanted to get this review out to you as soon as possible is the reason I have not tried it on those bands.

Technician class hams should have a ball when 10 meters starts booming and this antenna should get them on the lower CW bands now!

This antenna has so many possibilities in my opinion when you are limited for HF antenna space. Although the instruction manual plainly states that this antenna is not recommended for use inside....I know the experimenting nature of most hams will win over them and lots of hams will try it in their attics, garage, balcony, etc.

The thing that really impressed me about the TAK-tenna is the fact that during all of the fun I had with it on the air, I seemed to forget it was a "tiny" 40 meter antenna not longer than 30 inches! Maybe my review sounds like I am

biased......I am!
The TAK-tenna has proven itself to me and I believe you will be biased also when it gets you on HF when before, you could not!

I did not "review" the antenna for the statements concerning,
"Rotable Portable Stealth Perfect Backup Antenna"
on their web site because these facts are so obvious due to the shear size...or maybe I should say lack of size for the antenna.
This antenna would make a perfect antenna for field day, QRP, camping, backup for your wire antennas and Yagi's, when Mother nature or Murphy's law steps in. I am sure you can think of other ways to use it.
Backpacking adventures may be difficult but if you can divise a way to take it completly apart and then re-assemble it out in the field, then I don't see anything stopping you from having a great deal of fun on HF...out in the woods or on top of that mountain!......go for it! QRP anyone?

My overall score?

97!

(Out of a possible 100)

~~~~~~~~~~~~~~~~~~~~~~~~

Bottom line and some thoughts.......
Would I buy it if I had limited space for an HF antenna?
YES, and without any hesitation!
(with some final comments added)
97 overall score out of a possible 100...
That sounds too good to be true, but that's my opinion!

I must admit, Steve Tetorka of TAK-tenna has done a wonderful job in the creation of the TAK-tenna in filling a great gap in available antennas for those of you who are limited with HF antenna space. I had a few doubts concerning the performance of it but the results speak volumes.

No, it is not a full physical length 40 meter dipole, or Yagi up 100 feet in the air!
If it was, it would not be 30 inches long and the TAK-tenna company never states that it will out perform.....ANY....antenna.
But I can state that it certainly will get YOU on HF when you could not before!

Steve has designed this antenna using the knowledge of an engineer and with
the hands on experience of a seasoned ham radio operator while keeping you, the end user, in mind!

For those of you who are looking for a way to get on HF and are very limited to space with regular length dipoles or with a limited budget, then how can you go wrong by buying and using this antenna?
FOR IT'S SIZE, THIS IS ONE REMARKABLE ANTENNA!
I repeat...one remarkable antenna!

It is an electrical half wave length dipole, not some shortened version of a mobile whip or vertical, and in my honest opinion, why would you want to put up a commercial built vertical with all those radials for at least 2 to three times the price or more and find that it will not work much or any better than the TAK-tenna? Maybe you will get another 1/2 S unit better signal on a vertical....SO WHAT? You can't hear that small of a change! Do you listen to your S meter or the sound coming out of the speaker!

I don't think you will easily beat the on the air performance in such a small space!

I don't think you can beat the quality for the price!

I don't think you can beat the price compared with the performance!

So what is left? Murphy's Law.......he is still figuring out how to interfere with your fun on HF if you use the TAK-tenna...he has a very big, difficult job to do....
maybe he should bring in one of his twins to help him out!"
N4UJW HAMUNIVERSE.COM

BUY IT!

Was that a recommendation?.YES!....
and I don't recommend antennas!

NOW YOU KNOW WHY I REVIEWED THE TAK-tenna
and remember....I don't review antennas!

73 Don Butler, N4UJW Hamuniverse.com

Now I'm getting back on HF with the TAK-tenna to have some more fun,
I may even try it with QRP!.....
Shut up Murphy, go bother someone with a regular size dipole!

Where do I get it?

That's where!

The TAK-Tenna 80 is now available for 75/80 meters!

Update! See Actual Customer reviews on eham.net

Tak -tenna News! Confirmed TransAtlantic AND TransPacific contacts!

TAK-tenna, "LLC" WEB SITE DETAILS USED WITH PERMISSION

Disclaimers

POWERED BY HAM RADIO and AMATEUR RADIO OPERATORS!

A Homebrew 11.7 uHy Variometer

by W5JGV

Posted Jan 22, 2010, updated Jan 28, 2010

Just what you need to tweak your 600 Meter antenna.

This is an in-progress project!

I needed a simple variometer to be able to vary the inductance in the matching network for my 600 Meter vertical antenna. After considering several options, I decided to build a variometer using some easily obtainable parts. I did not need a lot of inductance change, about 10 uHy would work fine. The variometer described here allows a +/- 5.85 uHy swing while inserting a fixed 6.1 uHy inductance in the system.

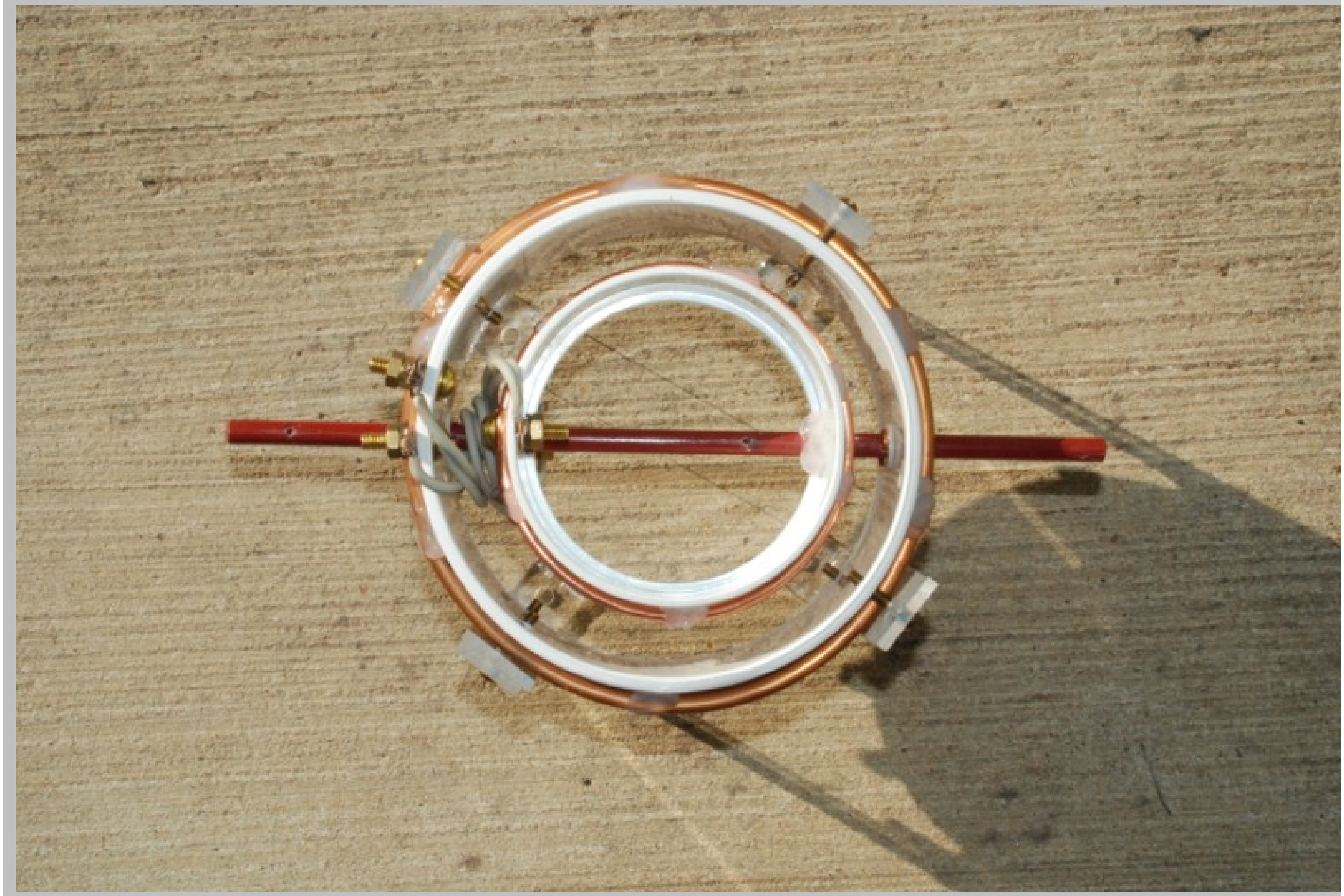
I wanted to use heavy wire because the antenna current in my antenna system at resonance is about 10 amperes. I knew from experience that #6 wire would be the smallest size that would not overheat in continuous operation. I chose 1/4" OD copper tube for the stationary outer coil and #6 AWG solid copper wire for the inner rotary coil. The coils are double spaced for optimum "Q" and because since I threw this unit together in a hurry, I used some salvaged tube and wire which was not quite straight. Using a closer turns spacing would present the possibility of an accidental short circuit.

For the outer coil form, I used a PVC pipe cap for 6" PVC pipe. I carefully cut out the closed end of the cap to end up with a length of PVC about 4 1/2" in length. The inner rotary coil form is a slip coupling for standard 4" PVC pipe. A hole was drilled through both coil forms across the diameter of the forms for the shaft.

The adjusting shaft was made from part of a fiberglass chimney sweep extension rod. The fiberglass rod measures not quite 3/8" in diameter, so a 3/8" hole provided proper clearance for the shaft to rotate freely in the outer coil form. A slightly

smaller hole was driller through the inner rotary coil, and the shaft was pressed through the coil form. Because the shaft has a tendency to slip on the smooth PVC of the inner form, a small hole was drilled crosswise through the fiberglass shaft just inside the inner coil form. A short length of #14 copper wire was inserted through the hole and glued against the inside of the inner coil form using RTV adhesive. Copper wire was used to avoid induction heating which would happen if steel or iron wire were used instead of copper.

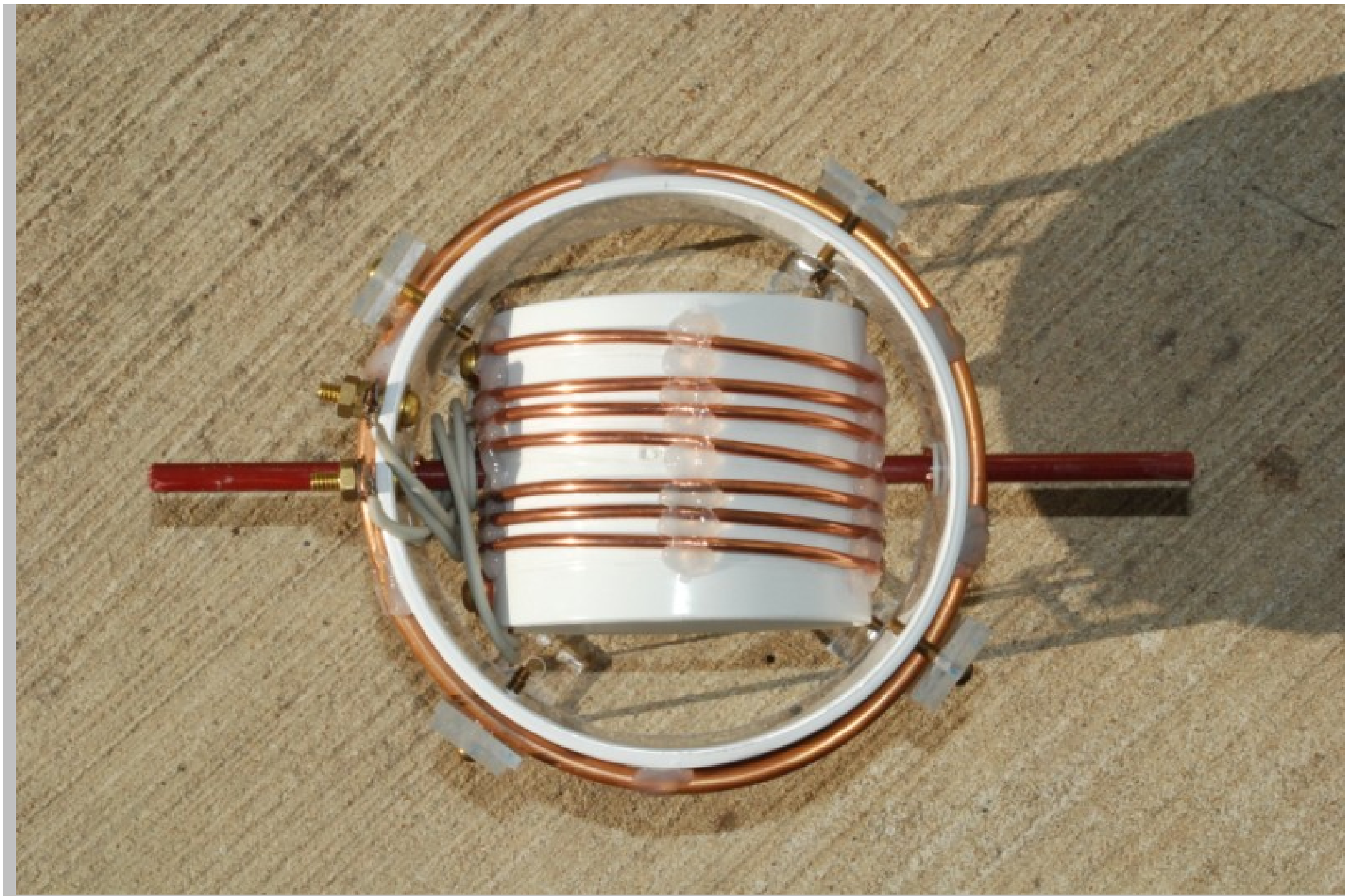
To keep the inner rotary coil from slipping sideways and hitting the outer coil, two more holes were drilled through the fiberglass shaft lust inside the outer coil form, one on each side. Two additional length of #14 copper wire were inserted through the holes and bent into a "Z" shape. The "Z" prevents the wire from dropping out of the shaft, and prevents the shaft and the inner rotary coil from slipping sideways out of position.



A top view of the variometer shows the just barely visible "Z" wire on the right side of the shaft, just inside the outer coil form. Note there is a plastic washer between the "Z" and the wall of the coil form to prevent scraping the coil form and causing binding.

The variometer is shown in the position for maximum inductance. In this position the inductance of the two coils are additive.. If the shaft is rotated 90 degrees, the inner coil is "flipped" over and the inductances of the coils are subtracting, and the variometer is at minimum inductance.

Here the variometer is shown at 50% inductance. The inductance is adjustable between 6.1 - 17.7 uHy, for a variation of 11.6 uHy. Although the two coils have almost the same inductance - 5.6 uHy for the outer coil and 6.1 uHy for the inner coil when measured separately- the minimum obtainable inductance is 6.1 uHy. This is because the magnetic fields from the two coils do not completely interact.



Looking down between the coils, you can see the grey connecting wires between the inner and outer coil forms. These wires are required because the two coils must be placed in series with each other for the variometer to function. Obviously these wires are much smaller than the tube and wire used on the coils, and they will get hot from RF loss when power is fed through the variometer.

What I did was to parallel two lengths of #12 AWG high temperature wire. The wire originally has a woven jacket of fiberglass over the grey insulation you see here. I removed the fiberglass because it made the wire much stiffer and increased the diameter.

The grey insulation is a Silicone rubber jacket that easily withstands the temperature of molten solder. Placing two wires in parallel will reduce the heating by dividing up the RF current flowing through the wire. Each pair of wires is wrapped around the shaft twice. When the inner coil is rotated 1/2 turn, the inductance changes from minimum to maximum, and the wires unwind by one turn. By wrapping the wires around the shaft, very little stress is placed on the soldered joints at the end of the wire and the center portion of the wire is flexed fairly evenly. As a result the connecting wires should last for many adjustment cycles.

There are four plastic legs that support the variometer. They are made from 3/16" thick Plexiglass. They are attached to the outer coil form by two brass screws that pass through clearance holes that are drilled through the leg. These screws then screw into threaded holes in the wall of the outer coil form. To add additional strength to the leg, a backup section of plastic is placed against the portion of the leg where it covers the windings of the outer coil. Heavier plastic could be used for the legs - I just happened to have a lot of this thickness plastic on hand, and already bent to shape.

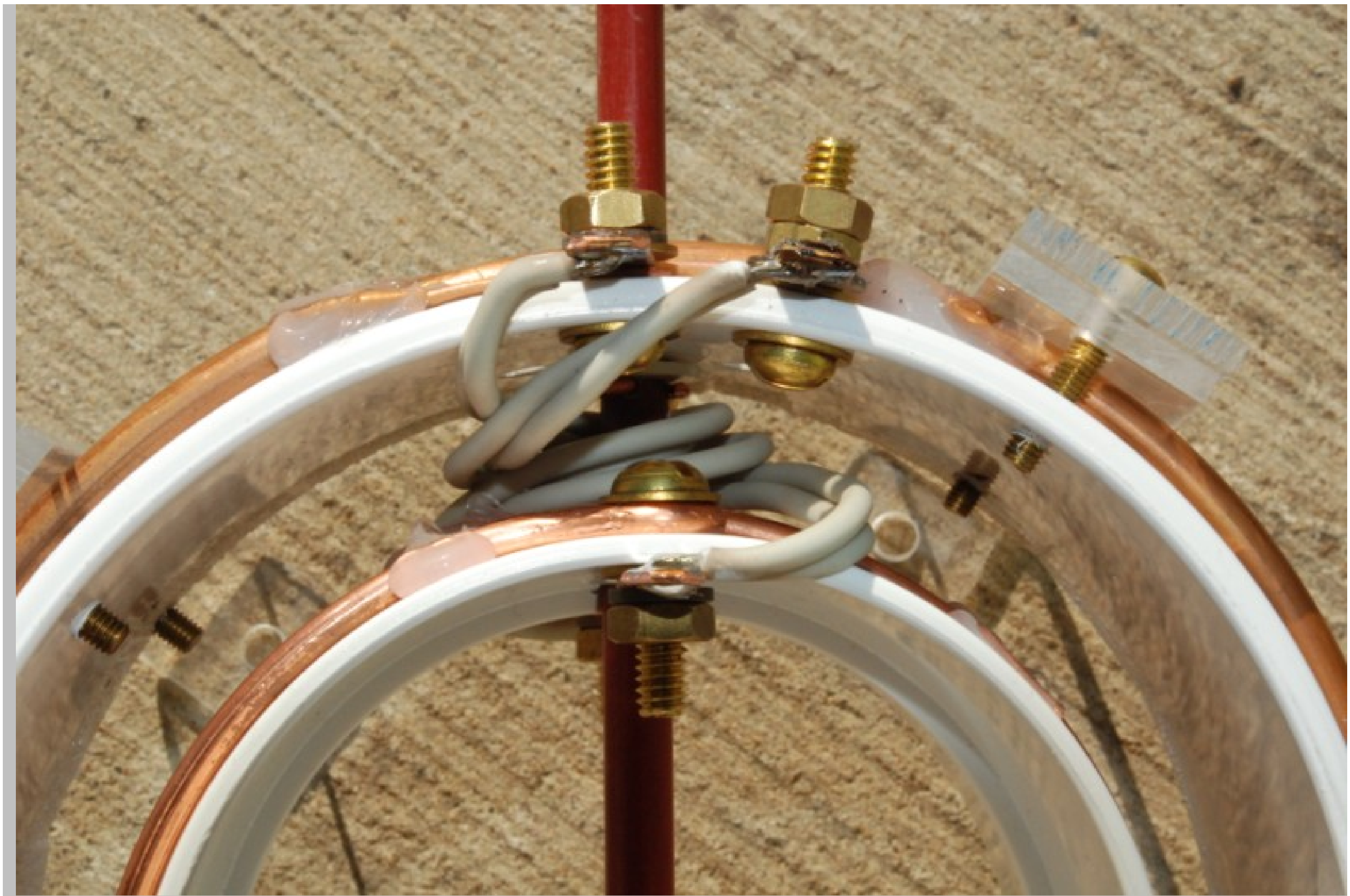
NOTE THAT ONLY BRASS HARDWARE MAY BE USED WITH THIS VARIOMETER.

Use of ferrous hardware will result in severe induction heating of the hardware and possible melting of the plastic.

Note that all the hardware seen here is brass. no steel or iron allowed!!

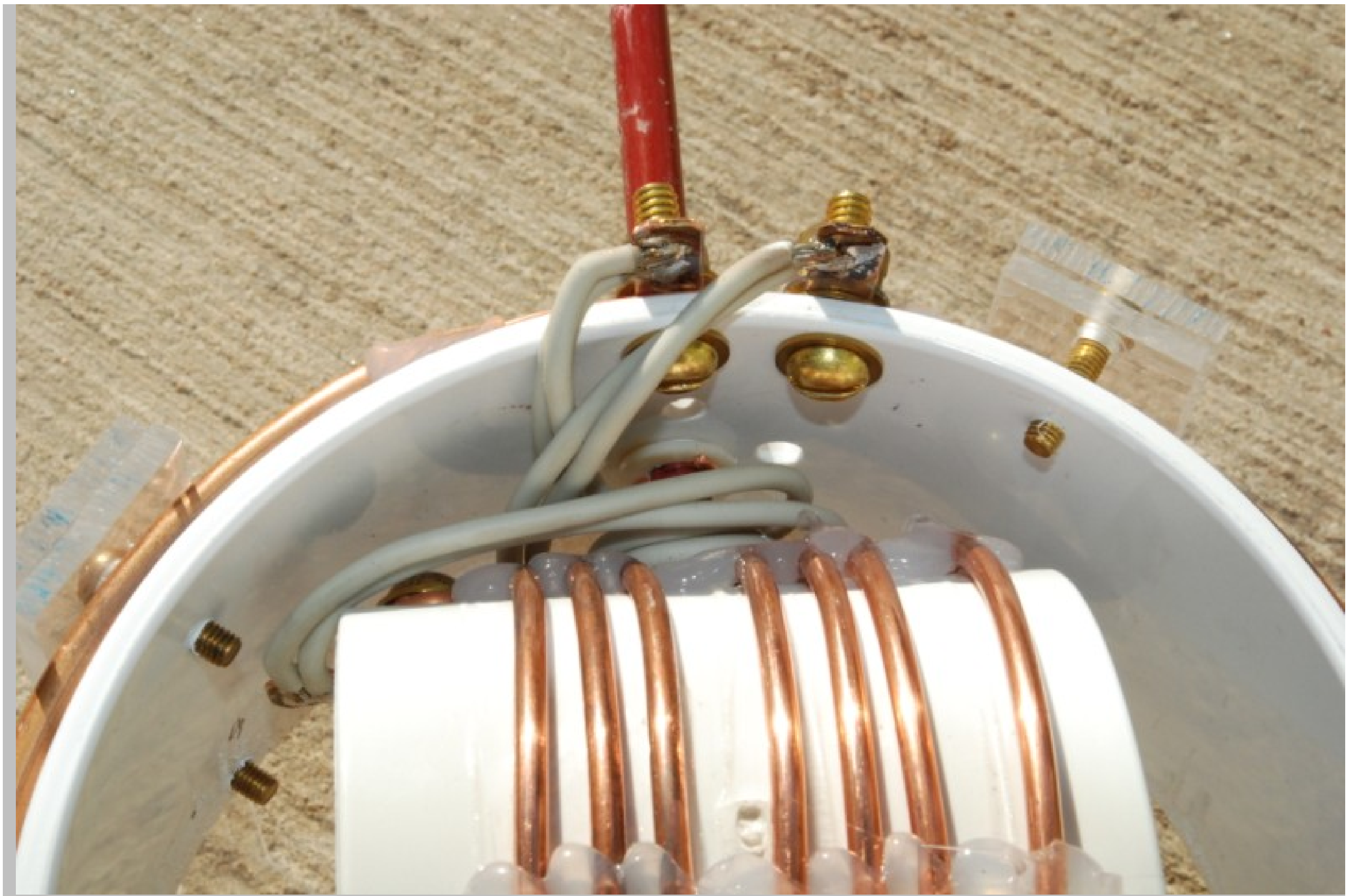
The RF flow through the variometer is as follows - One external RF connection is made to the 1/4" brass bolt barely seen at the bottom center of the photo. After passing through the outer coil, the RF goes from the right hand 1/4" brass bolt at the top of the outer coil through one pair of flexible leads to one end of the inner coil. After passing through the inner coil, the RF exits through the second pair of flexible leads and ends up on the left hand top 1/4" brass bolt which is the second external connection of the variometer.

If you look at the fiberglass shaft where it enters the inner coil form at the top of the picture, you can see the copper wire that is used to hold the shaft to the inner coil form. Also visible ion the picture is a lot of RTV adhesive that was used to hold things in place. The RTV adhesive is a good choice as it is heat resistant and flexible, allowing the tire and tube to flex slightly as the coil heats up in operation.

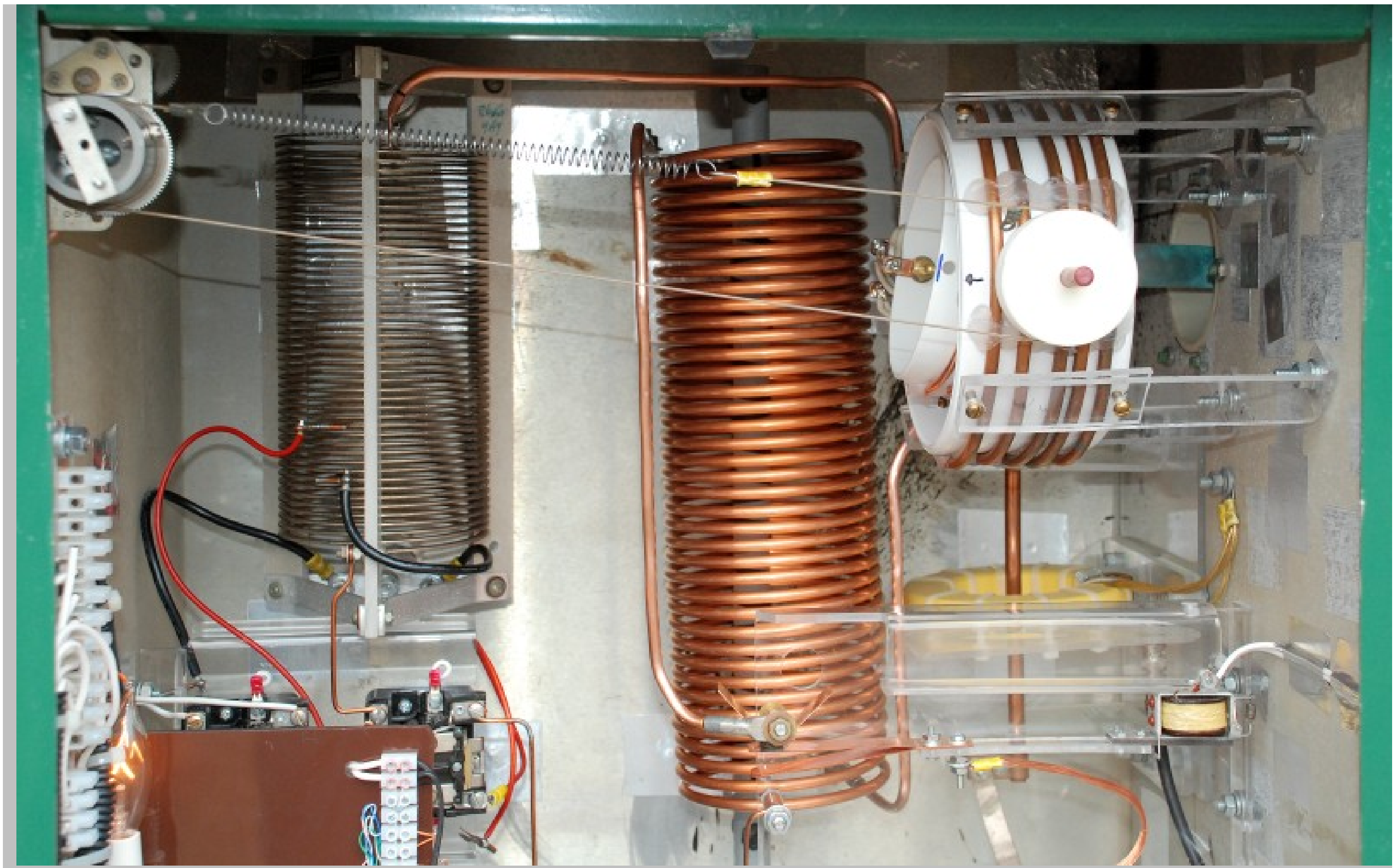


All wound up, and no place to go but up.

This photo shows the variometer in the minimum inductance position with the connecting wires wound twice around the shaft.



Here the variometer has been set to 1/2 inductance position. You can see that the wires are slightly unwound from the shaft.



Here is the completed variometer installed in the antenna tuning cabinet at W5JGV - WD2XSH/7.

The matching system for the 600 Meter antenna consists of two loading coils in series. The first coil, at the left of the picture, is an edge wound copper coil. The black wire connecting to the tap on the lower portion of the coil adjusts the total amount of inductance in the system, and sets the resonant frequency of the antenna system. The red wire is the feed point tap from the transmitter, and adjusts the load impedance for the transmitter.

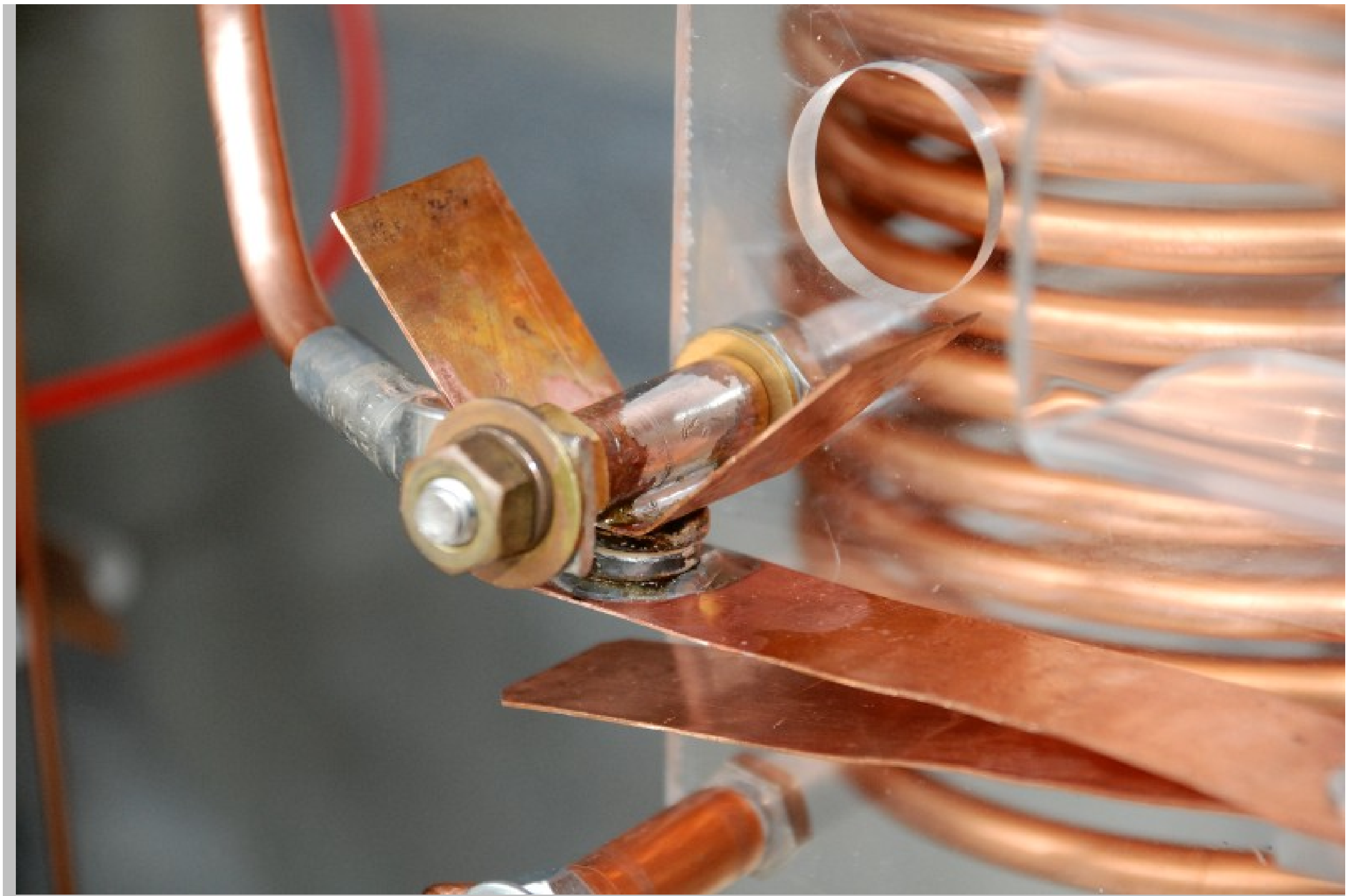
The top of the edge wound coil is connected to the input of the variometer with a length of 1/4" copper tube. the output of the variometer is connected with 1/4" copper tube to the bottom of the right hand coil, which is wound with 1/4" copper tube. The connection from the top of the copper tube coil to the upper (600 Meter) contact of the antenna changeover relay is made with 1/4" copper tube.

The antenna changeover relay is constructed from a relay coil salvaged from a surplus high voltage relay. I installed the coil upside down on a plastic frame. The armature of the relay is extended by a length of plastic. The armature extension holds a pair of copper strips which are connected to a length of flexible copper wire. The flexible wire goes to the antenna through the RF current transformer which is used to measure the antenna current. The copper strips are work hardened by repeated flexing, then flattened and bent apart slightly to allow spring action when the contacts make and break during operation.

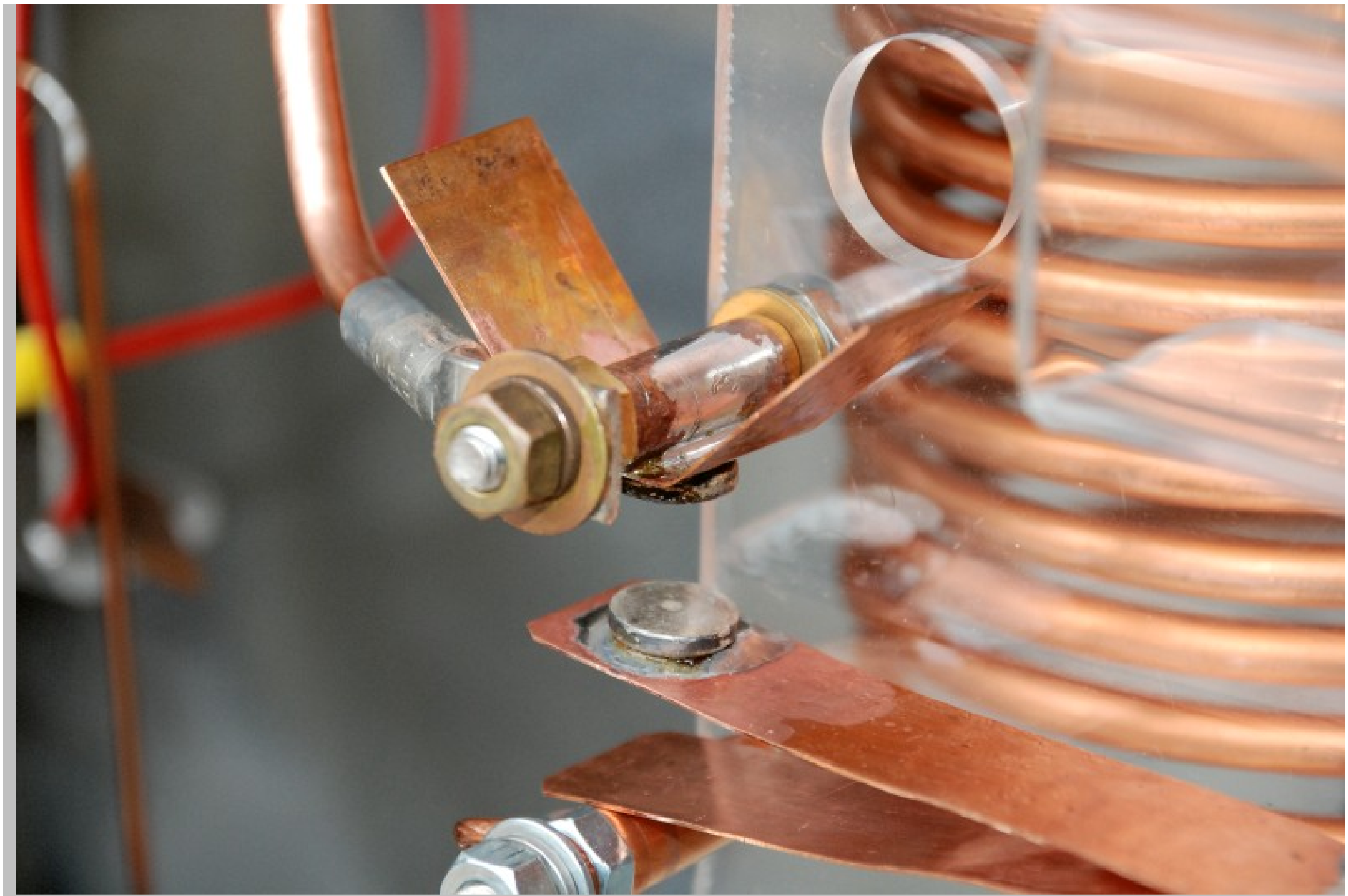
The lower fixed contact is a length of copper tube, against which the copper strip rests when contact is made in the lower (deenergized) position of the relay. The upper (energized) contact was originally the same as the lower contact, but due to the high current encountered during full power operation at 600 meters, the copper to copper contact burned badly and failed. This was replaced by a set of coin silver contacts which were soldered on to the copper strip and the copper upper contact tube.

Also visible is the variometer drive motor on the left side of the cabinet and the plastic coated stainless steel fishing leader and tension spring that is used to rotate the variometer. The white drive wheel on the avriometer was fashioned from a 1/2" thick peice if HDPE plastic. It has a slight half-round groove to prevent the drive wire from slipping off the wheel. Two 1/4" diameter brass set screws were made to attach the wheel to the fiberglass drive shaft. The set screws are inserted into drilled and tapped holes spaced 90 degrees apart through the drive wheel.

This view shows the antenna changeover relay and the matching networks which were used for matching the antenna on the 40 and 20 meter bands. They are not used at this time.



The 600 Meter antenna changeover relay contacts are shown here in the closed position. the contacts are 1/2" in diameter and 3/16" thick. A :V: shaped copper strip has been soldered on to the stationary contact to act as a additional heat sink for the contact.



The 600 Meter contacts are in the open position, note that the lower contacts for 160 - 20 meters are in the closed position.

I hope this project will give you some ideas about how you might construct a variometer for your antenna system. If you need a really BIG variometer, check out this one and HERE and HERE that I built for my 166.5 KHz antenna system.

73, Ralph W5JGV

[Home]

Homebrew Buddipole Variant

By

Paul – AE5JU

History: The Buddipole is a portable dipole using telescoping whips on the ends of center arms, with loading coils between the arms and whips. Originally a homebrew item made from pvc pipe fittings, and rather flimsy. Later they produced a commercial version.

http://www.qsl.net/w3ff/

http://www.buddipole.com/buddipole.html

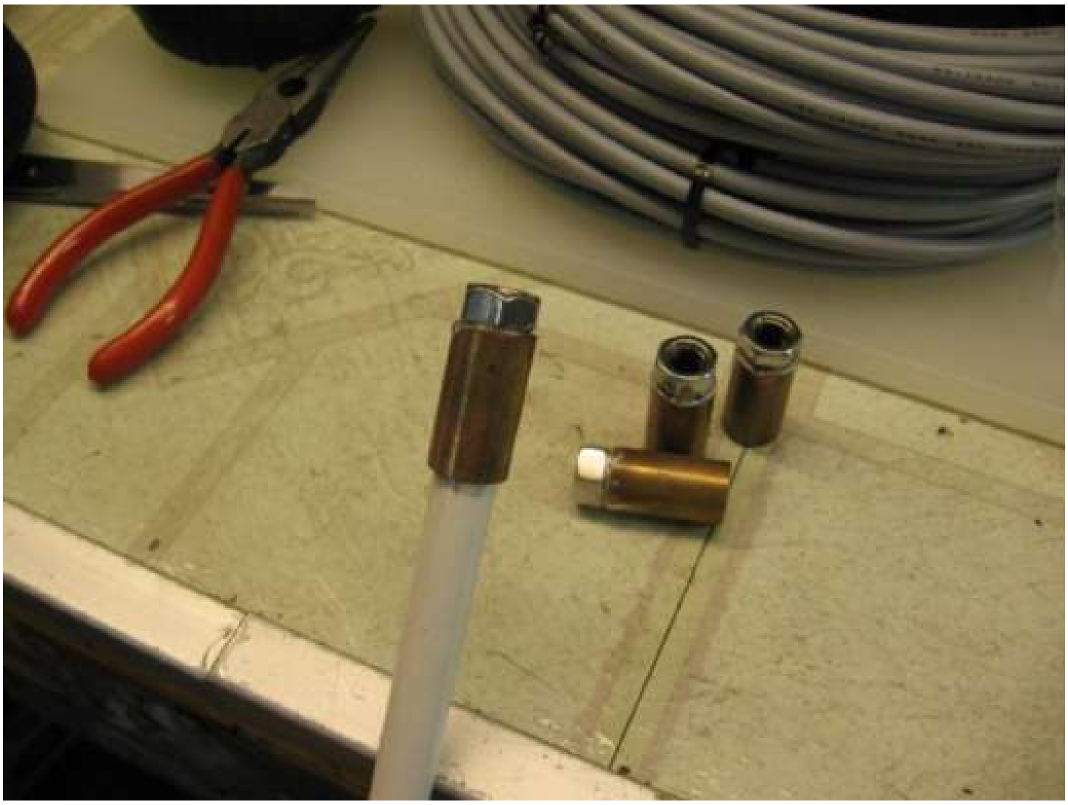
Just what we need for emergency services, portable, the ability to work various HF bands. So, mine's going to be a little stronger than the pvc homebrew Buddipole. I live in a place you can for sure buy hardware!

01 Bench Grinder Work — Those are 3/8-24 hex joiner nuts I got from HamCQ.

http://www.hamcq.com/whips-quick-disconnects-capacity-hats-extensions-antenna-springs/nuts-3/8-24-by-1-inch/prod_129.html

They are really brass with a nickle plating. Also some 1/2" ID bronze sleeve bearings. (1/2" ID x 1-1/8" long) Why? Brass and Bronze are non-inductive, and this will be near the loading coils. I ground down the outside of the nuts to slip fit halfway into the bronze sleeves. The bronze sleeves were obtained from the local hardware store. You'll see why in a minute. I am the Grand Master of the bench grinder, almost. Fellow ham club member Frank, noticing my skint up knuckle said, "Why didn't you just slip the nut over a wood dowel and..." So NOW you tell me, Frank!

02 Soldered — Soldered together with torch, flux and solder, just like soldering copper water pipes. Cleaned up well after, scrubbing off all remnants of the acid flux. There were a few drips of solder inside, so I cleaned up those with a Dremel tool.



03 Ends Fitted — This is what they are for. These things will be epoxied onto the ends of 1/2" diameter fiberglass electric fence rod. I got the fiberglass rods from Kencove Farm Fence Supply. These are VERY cheap, about $2.50 for each 5' x 1/2" rod. You need two 2 1/2' pieces for each Buddipole.

http://www.kencove.com/fence/detail.php?code=F12-5SG

Length of the arms, from center of dipole (even with coax connector) to end of the hex nut, 31".

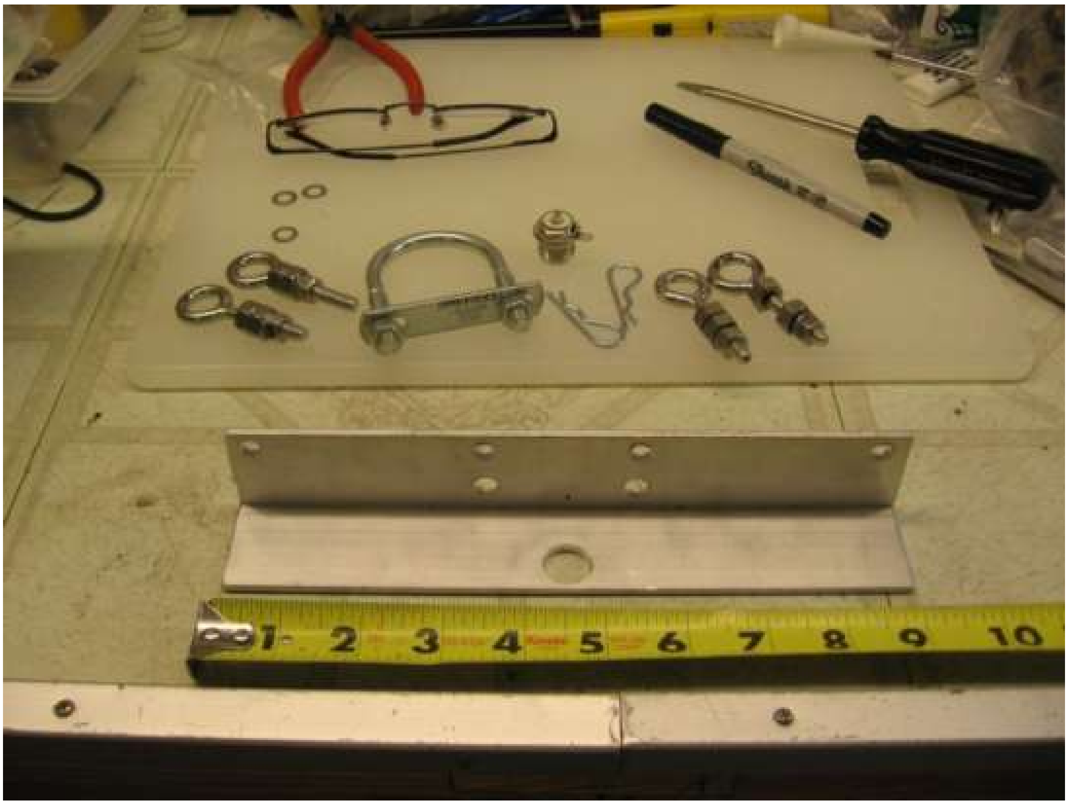
04 Whip Mounted — This is how it will go together. These black whips have a 3/8"-24 thread on the end, just like Hamsticks and other mobile antennas. And as luck would have it, they thread right into those nuts I soldered into the bronze sleeves and epoxied onto the fiberglass rods. The antennas droop. They all do, so get over it. These whips were obtained from www.buddipole.com for $18 each.

http://www.buddipole.com/lotewh.html

These are not the standard Buddipole whips, they are 9 1/2' long.* Along with the center sections, and by varying how much of the whips are pulled out, we should be able to bypass the loading coils and adjust the antenna to resonate on 15, 12, and 10 m.

With coils, this antenna should be able to be tunable to 80m, 40m, and 20m.

* MFJ has some 10' and 12' telescoping whips with the same 3/8"-24 thread.



05 Bracket. — This is a 9" long piece of 1/8" x 1 1/2" angle aluminum. I've drilled some holes. Big hole in center is to install a chassis mount SO-239 socket. Later some jumper wires about 4" long will be soldered to the center and ground tabs with Anderson Power Pole connector on the ends. You may use ordinary spades, or other connectors. I have a big bag of Power Poles here so I'm going to use them. They give reliable connection and are not at all fragile.

Anderson Power Pole connectors can be found here:

http://www.powerwerx.com/

You will also find a nice Power Pole installation tutorial here:

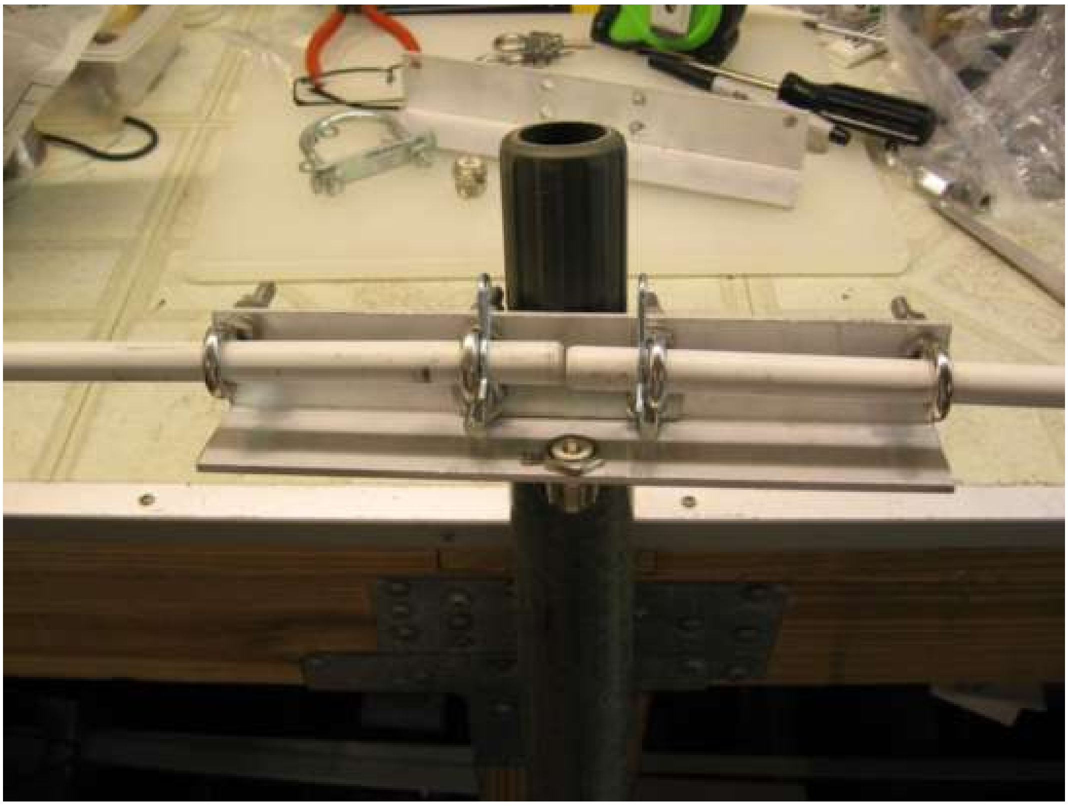
http://www.westmountainradio.com/supportrr_RC.htm

http://www.flyrc.com/articles/using_powerpole_1.shtml

In the background you can see some stainless eye bolts. There are two large nuts slipped over the shank of each eye bolt, and then the properly fitting nut. Those large nuts are used as just spacers. The reason is, there is an unthreaded section of the shank of the eyebolt and you could not get it tight with just the original nut.

The eye bolts go through the four holes across the top of the angle. It just so happens they have a 1/2" diameter hole. This allows those 1/2" fiberglass rods to fit through.

There is a U-bolt which will mount in the lower holes toward the center. This is also stainless steel, and will just fit around the top end of the mil surplus fiberglass poles you can buy on eBay.



06 Bracket assembled — I've cut the 1/2" fiberglass rods in half. They ended up being 3/16" short of 30" each. The ends with the nuts were epoxied on. Tomorrow I'll get some little brass screws, cross drill, and put in the screws to make sure the ends don't come off.

Those fiberglass rods ended up being 30 1/2" long overall, out to the hexnut on the end. We'll have a conductor run along those later to form the center section of the dipole.

You can see I have drilled a small hole in the rods, and they are held in place by slipping "hairpin" hitch pins through those holes.

I have installed the socket. Now it's starting to shape up.

The green fiberglass mast poles are military surplus ones you can find on eBay and at hamfests. They are 48" long. They are not really antenna masts, but are used to hold up camoflage netting. They sell for about $20 for a 12 pc set, with about another $20 or so for shipping. You only need about 4 or 5 of these mast pieces, so, split the set with a friend like I did.

Used masts
http://cgi.ebay.com/ws/eBayISAPI.dll?ViewItem&item=150315895044

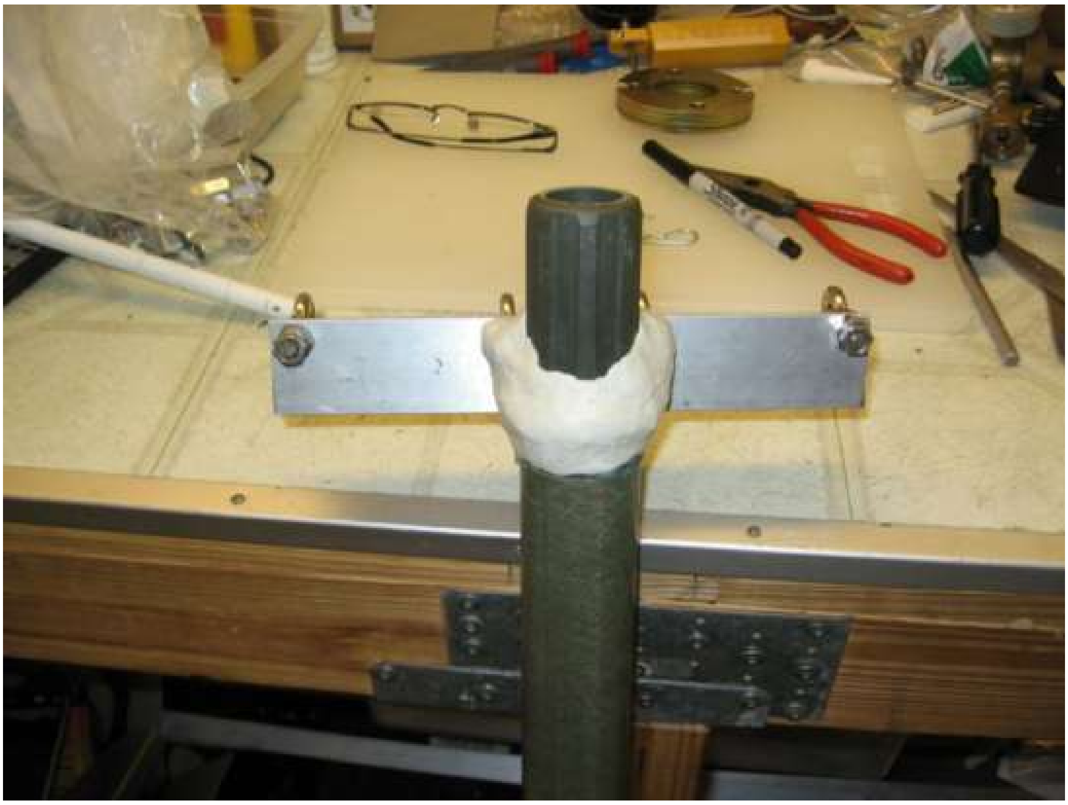
New masts http://cgi.ebay.com/ws/eBayISAPI.dll?ViewItem&item=150316253303

Everything is a little "loosey-goosey" right now, just finger tight. I'll take it all apart in a bit and reassemble with locktite on all of the nuts and bolts, and the nut on the SO-239 socket.

I'll use a Dremel cutoff wheel and cut off the excess threads on the eye bolts. Also, I will make the U-bolt only just tight enough to make the bracket snug. It is tightening around the plastic end of the mast tube. To keep it from shifting around, before I install the U-bolt for the final time I'll put a glob of epoxy putty between the pole and bracket. The U-bolt nuts will get an application of Locktite, also.

The bracket can be left on that top section for transport and storage. The arms come off, the coax comes off, there is no need for the bracket to come off.

First I used a Dremel fiber cut off wheel to remove the excess length of the eyebolts. I made sure there were no sharp bits left. I used plenty of Locktite to make sure everything stays tight.



07 Epoxy Putty.jpg — I put a wad of epoxy putty (similar to Plumber's Epoxy Putty, hardware store or Walmart item) between the bracket and the mast end. I snugged the U-bolt, but not so hard as to crack the end of the mast. You could tighten it all day and never get it tight enough to not wiggle. So, to prevent breakage, I just barely snugged it up, then packed epoxy putty around the back. Now it won't wiggle, it won't come off, and that part can just stay on that section of mast. No need to remove it.

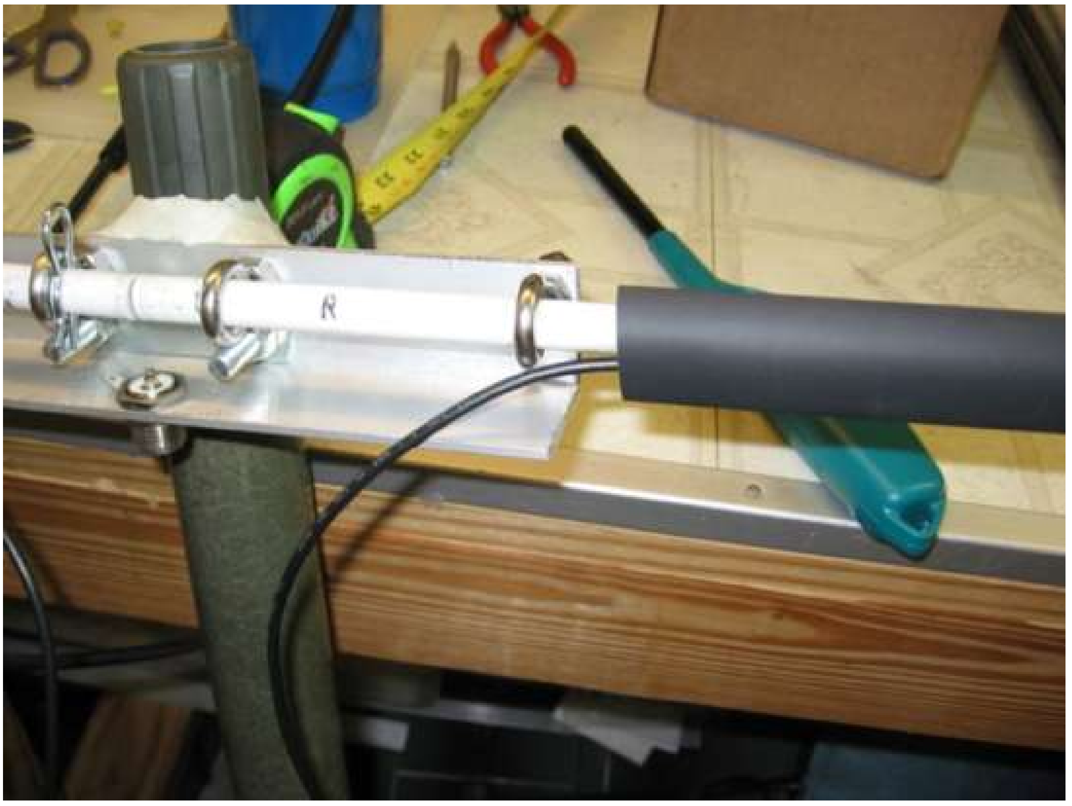
08 Teaser.jpg — This is a mockup, just a teaser to show you where we're going with this. Right now just one section of mast is slipped over the tube of PA Speaker Tripod Stand.

http://www.parts-express.com/pe/showdetl.cfm?Partnumber=245-010

These are somewhat larger, stronger than the ones sold with the commercial Buddipole. The fiberglass arms are installed, and the whips screwed on and extended. I will still have to make the coils, which will go on the ends of the fiberglass arms. Yeah, the whips sag. That can't be helped, and that is going to happen no matter what. Won't hurt a thing. But those fiberglass fence rods sure don't sag! That's some good stuff. Makes me want to look around and see what else I can make from them. There will be loading coils that will slip onto the ends of the fiberglass arms. There will be 14 ga wire that will go along the fiberglass arms to form the middle section of the dipole. Those antenna wires will be held onto the rods with heat shrink tubing. Anderson Power Poles will be used for all those connections.

09 Arm Terminals.jpg — I cross drilled and put in some #6 x 1" brass screws. Brass, all hardware brass because it is non inductive. Why? Because the loading coils for the lower bands will be nearby. I put a little glue on the screw, put it through. A little Locktite on the screw, a brass washer, and a brass nut. Then we have some binding post thumbnuts. Those are left loose. This screw does two things, pins the end nut assembly so it won't fall off, and it provides a way to complete the electrical connection to the telescoping whips in the ends.

10 Wiring Arms.jpg — Here some 14 gauge insulated wire is held in place with some short pieces of 3/4 heat shrink, shrunk in place. This 14 ga wire will be the middle part of the dipole.

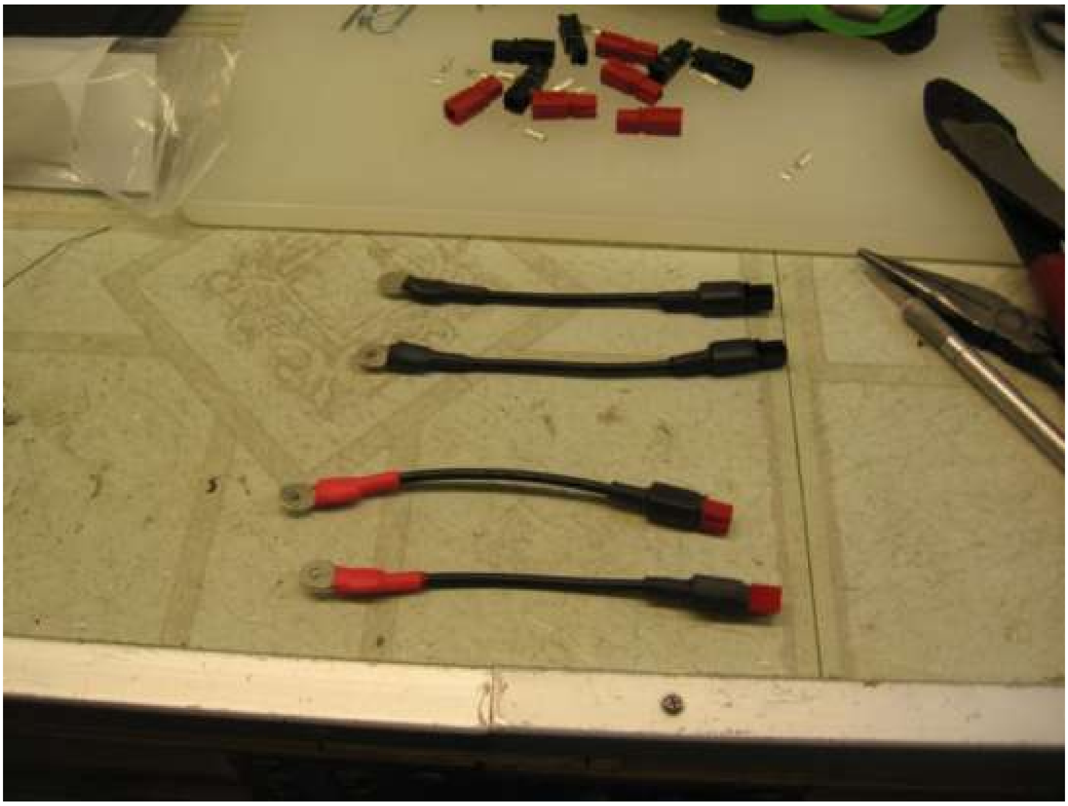


11 Heat Shrink Arms a.jpg — 3/4" heat shink is slipped over the fiberglass arms and wire, to about 1" from the end of the aluminum angle center support.

12 Heat Shrink Arms b.jpg — On the other end, the end of the heat shrink is about 6" from the outer end.

13 Heat Shrink Arms c.jpg — When I shrunk the tubing I did both ends first to anchor them in place, then worked toward the middle. Don't worry about trapping air bubbles. The air will easily leak out along the wire and rod. You will have to work the wire to be more or less straight, but even if the wire is a little crooked it won't hurt a thing.

Now we hook it all up.



14 Jumpers to Whips a.jpg — These are short, overall length 5". You only need to make up one red and one black jumper. I have two of each here because I am building two Buddipoles. These are made from the same 14 ga insulated wire as the center. Anderson Power Pole on one end and a #6 ring terminal on the other, with one of my favorite materials once again, heat shrink tubing!

15 Jumpers to Whips b.jpb — Power poles have been added to the pieces of wire coming out of the heat shrink tubing on the fiberglass arms. The gap between the end of the heat shrink on the arm and the nut on the end, where the whip will be screwed on, is where loading coils will be placed later on so that this antenna can be made to work on 20, 40, and 80/75 meters. Make the wire coming out of the heat shrink on the arm long enough to connect to the short jumper on the end. This is so that the coils can be bypassed, or not used at all, for use on 6,10, 12, 15, and 17 meters. For the lower bands, requiring the loading coils, those coils will have Power Poles on each end, too. Spade lugs could be used, but I like the Power Poles better.

16 Center wired.jpg — You can see here how I finished the center and connected to the arms with Power Poles. As you can see, we are now outside... somethings gonna happen!

17 Whips screwed on.jpg -- Screwed on and fully extended. The dipole is about 12' on each side.

18 PA Spkr Tripod.jpg — Heavy duty PA speaker tripod from Parts Express

http://www.parts-express.com/pe/showdetl.cfm?Partnumber=245-010.

19 Its UP.jpg -- There it is, up with 4 sections of mast, about 17' up.

23 and 26

I hooked it up to my Yaesu FT-897. It was getting dark and dew beginning to fall, so I didn't do much testing.

I turned the FT-897 down to 5 w power output with the coax connected directly to the output of the radio. With the whips all but the last segments extended, on 15 meters I had a SWR reading of 1.2:1. Hey! Not bad!

I checked SWR on 17 meters with the whips fully extended and got 1.6:1. Check ing 15 meters again, 2.6:1 with the whips fully extended. The tuner quickly had both bands down to 1.1:1.   I'm sure it will be tunable on 12 and 10 meters by simply pulling in the whips but I didn't have time to do that before it got dark.

In case you were worried, yes, this will blow over easily. But now I have some guy rings to attach to the mast used with bright orange (to hopefully prevent tripping) parachute cord and 1' long tent stakes.


28 It's up, 40 meter coils in use, and the whip ends adjusted for best SWR.

29 Closeup. The coils are just slipped over the ends, and the jumpers hooked to the coils. Anderson Power Poles used here, too.

30 Ferrite Beads. Four Snap On Ferrite Beads (FSB-1/4) from Palomar-Engineers.com were snapped onto the coax to act as a choke. These beads are for 1/4" cable, such as the RG-8X I used. Again, I have put bands of heat shrink tubing on the choke beads to make sure they stay snapped on.

I later added a 5th bead on the advise of Palomar Engineers. They also offer a ferrite choke balun kit.

31 Red Coil. The coil form is 1-1/2" pvc sink drain pipe. There are 28 turns close wound of 20 ga insulated wire. The is about 1-1/2" of wire from each end of the coil with Anderson Power Poles for connection. The "red side" of this dipole is connected to the center conductor of the coax. All Power Poles used are red, and the coil wire is red. This should give people a hint, red on one side, etc.

32 Black Coil. This coil is also on 1-1/2" pvc sink drain pipe. There are 24 turns close would of 20 ga insulated wire. Yes, good observation, the coils are not identical.   This coil is on the "black side" which is connected to the shield side of the coax.

Fine tuning of SWR is done by adjusting the whips. Just as the coils are not symmetrical, neither are the whip lengths. For 7.225 mhz, I came up with these adjustments for SWR = 1.3:1.

Red side whip, 5 1/2 sections, or 103" of whip pulled out.

Black side whip, 5 sections minus 3", or 92" of whip pulled out.

Probably a little better could be done, but I was happy with 1.3:1.

So, why are the coils assymetrical, and the whips pulled out to different lengths?

Good question, and one I asked myself.

When a dipole is up some distance, what, 1/2 wavelength? it is 72 ohms. Closer to the ground, as most people would put them, they are closer to 50 ohms, and a good match to 50 ohm coax.

But lower, such as this antenna will be used, the impedance will drop to around 30 ohms. By placing the feedpoint offcenter the antenna presents a higher impedance, closer to the 50 ohms of the coax. SWR can be lower in such a case.

Now, I thought, you've got to be kidding. At first I had both coils symmetrical, the whips pulled out equally, and sure enough, I had problems getting SWR below 3:1. I'd push both in or out a little, and get down to 3:1, then a little more, and it was back up 5:1 or higher. Then I just went with the flow, tried it like this, and sure enough, I was soon getting SWR's down, 1.9, 1.6, 1.4:1, and lower.

Make sure the knurled nuts (jumper binding posts from end of fiberglass to whips) are tight.

Coils for 20 meters were fabricated, using the same 1 1/2" pvc sind drain pipe. Red coil is 8 turns, 20 ga insulated wire close wrapped. Black coil is 6 turns.

For 20 meters, whips were, red side, 5 1/2 segments (total whip length 104"). Black side, 5 segments + 3" (total whip length 98"). This resulted in 1.2:1 SWR with tuner bypassed, at 14.240 mhz.

I tuned around and was hearing an old acquaintance from my SWL days, Angelo in Michigan, almost 1000 miles away, on 14.245 mhz. I waited for my turn, CQ'd him, and he came right back. We had a nice 25 min QSO. Signal report 59+15 both ways.

The next day I set up in the Park for an informal mini-field day.

Now I ask you, is that not a great picture? Bandstand, American flag, fountain on the left, playground in the background. Nice big shady oaks. Just a very relaxing place.

The Husky Power Center battery held up well for about two hours. From the Louisiana Gulf Coast I made a number of good QSO's, Iowa, Wisconson, Pennsylvania, Connecticut, Maryland, New York (a nice 25 minute chat about stereo gear, and he used to work at a TV station near me). Very good signal reports, too, from 56 to 59+20. This was all up on 20 meters.

By the time I shut it down, when I would key the mic the voltage would drop to 11.3 v, with 12.4 v on receive. Still, the radio did not shut down due to the low voltage. That was good. I don't know just how low voltage it will tolerate.

The Yaesu FT-897, LDG AT-897 tuner and antenna gave great performance.

The whips have 6 sections, and the left side (6 turn black coil) was pulled out to 5 sections plus 3" (total 98" whip length). The right side, (8 turn red coil) was pulled out 5 1/2 sections (total 104" whip length). The antenna, with the 20 meters coils, on 14.240 mhz gave an SWR reading of 1.2:1 with tuner bypassed.

Police cruised by and did not even slow down to look.

Talking on the radio in the park is fun.

Parts List

Fiberglass masts, carry bag, AND guy rings.

Used http://cgi.ebay.com/ws/eBayISAPI.dll?ViewItem&item=150315895044

New http://cgi.ebay.com/ws/eBayISAPI.dll?ViewItem&item=150316253303

—-

Tripod Stand

http://www.parts-express.com/pe/showdetl.cfm?Partnumber=245-010

—-

1/2" x 5' fiberglass rods, Item # F12-5SG. One required for one antenna, will be cut in half.

http://www.kencove.com/fence/detail.php?code=F12-5SG

—-

Hexnuts for ends of arms to mount whips

http://www.hamcq.com/whips-quick-disconnects-capacity-hats-extensions-antenna-springs/nuts-3/8-24-by-1-inch/prod_129.html

—-

Bronze bushings from the first photo are 1/2" ID x 1-1/8" Long. Hardware store item.

—-

9-1/2' long telescoping whips from Buddipole

http://www.buddipole.com/lotewh.html

MFJ also makes some 10' whips that will work as well.

—-

Anderson Power Pole connectors

http://www.powerwerx.com/

How to install Powerpoles:

http://www.westmountainradio.com/supportrr_RC.htm

http://www.flyrc.com/articles/using_powerpole_1.shtml

—-

Split Beads for 1/4" coax (get the size you need for your coax) FSB-1/4 fits RG-8X.

Use 5 beads or buy Palomar Engineer's ferrite balun kit.

http://www.palomar-engineers.com/Ferrite_Beads/ferrite_beads.html

—-

SO-239 "chassis mount" socket

Heat shrink tubing - 3/4", 1/2", 3/8"

—-

Tent stakes, orange paracord, and other items can be found online.

Tune Around!
SEARCH

CQ-Calling All Hams!
About Hamuniverse
Antenna Design
Antenna Safety!
Ask Elmer
About Batteries
Code Practice
Computer Help
Electronics
FCC Information
Ham Hints
Humor
Ham Radio News!
Post Reviews
Product Reviews
Ham Radio Videos!
HF & Shortwave
License Study
Links
Midi Music
Reading Room
Repeater Basics
Repeater Builders
RFI Tips and Tricks
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MINI HORIZONTAL "V" 2 ELEMENT "HAMSTICK" 20M BEAM.

by Russ Wilson, VE6VK

Material Required:

4ea 20M "Hamsticks"
1 inch diameter boom 4 ft 6 inches long.
1 aluminuum mounting bracket driven element.
1 aluminum mounting bracket reflector.
4 insulated CB mounting kits 3/8" by 24 TPI (2 can be un-insulated for reflector.
Wire for hairpin match. 14 gauge electrical wire with insulation removed.
Coaxial balun 12.5 ft RG58 wound on a 1-1/4 inch white PVC 8 inches long.
Bolts, nuts, lock washers for mounting.

CONSTRUCTION:

Two aluminum brackets are made out of scrap aluminum 1/16 inch thick or a little heavier if desired. The brackets are bent into shape as per the photographs to allow element kits to be mounted so the elements are at 90 degrees from one another.
At 15 ft off the ground, measurements were made of the Driven element using an electrical 1/2 wave length of RG58 as a 1:1 transformer. Using the antenna analyzer from the ground the following measurements were noted.
Impedance 25 ohms
SWR 2:1
The antenna was resonated to 14250 Khz.

A hairpin match was made using #14 gauge electrical wire with insulation removed. Two lengths 18 inches long are required. (See Arrl Antenna Book for more on hairpin matching)
The two wires have solder lugs placed on them at one end. These ends are connected to each mounting kit terminal for the Driven Element. The wires are spaced 1-7/8 inches from each other and are arranged so they are approximately 1 inch above the boom. See photographs for details below.
A couple of wood or plastic spacers are used to keep the wires separated. Also a piece of 3/8 inch thick plastic is mounted on the boom, 2 holes drilled for the wires to pass through for extra support. After the hairpin is mounted and a temporary shorting bar placed across the hairpin, the antenna is placed in its original position and further readings taken, adjusting the sliding short across the hairpin, until the impedance of 50 ohms is reached. A little juggling of the whips to bring the driven element back to 14250 Khz is necessary. After a few minutes of testing and adjustment of the hairpin short and the whips, the resonant frequency of 14250 Khz is reached and the impedance reads 50 ohms. The wire short on the hairpin can be permanently soldered.

Measure the length of the whip on the driven element, multiply this by 6% and add this to the length of each driven element whip. In my case it was 38.5 inches. 2.3 inches was added to each reflector whip. The boom length was experimented with and the length shown seemed to be optimum for the short boom. The reason for the resonant frequency chosen was my own personal preference as I do quite a lot of operating for IOTA 14260. If you wish to operate CW or any other preferred frequency you can choose by figuring out the frequency response of the beam is approximately 200Khz. The photographs should assist in figuring out the brackets etc. The actual measurements from tip of whip of each half element to boom.

Driven 1/2 element = 86.625 inches (220.0 Cm)
Reflector 1/2 element = 91.75 inches (233.0 Cm)
This is using the regular Lakeview Hamsticks.
The PHF type are much better and you do not have to readjust or mark the whips.

I worked XZ7A on CW with the beam and 80 watts, so apparently it works.
A frequency run and measured SWR is as follows:

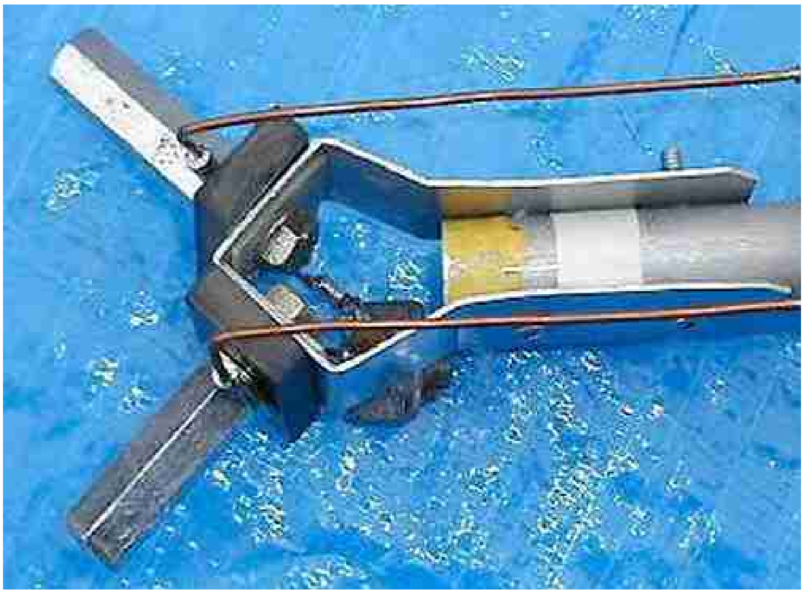
14100	2.5:1
14130	1.5:1

14140	**1.3:1**
14150	**1.2:1**
14165	**1:1**
14202	**1:1**
14250	**1:1**
14300	**1.1:1**
14350	**1.4:1**

The finished product!

The not so "Ugly" balun

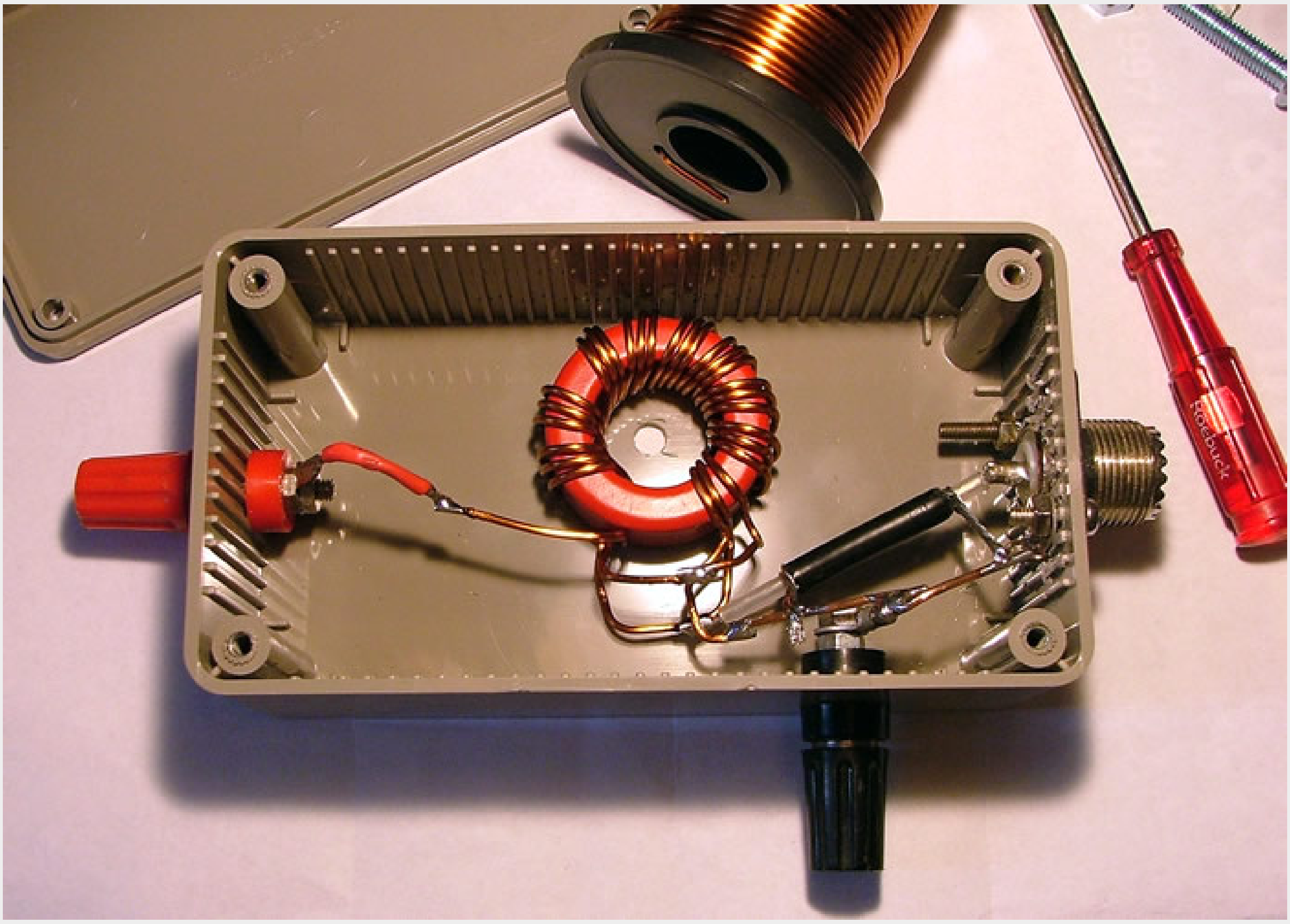
Note the 90 degree angle between element attachment mounts
and the 45 degree angle to the boom of the driven and reflector elements!

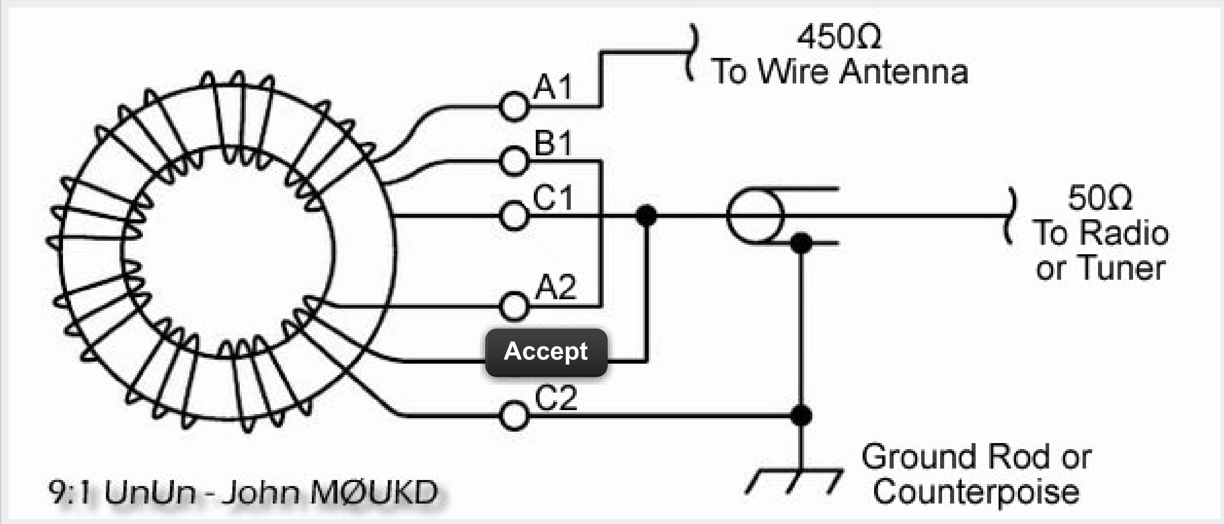


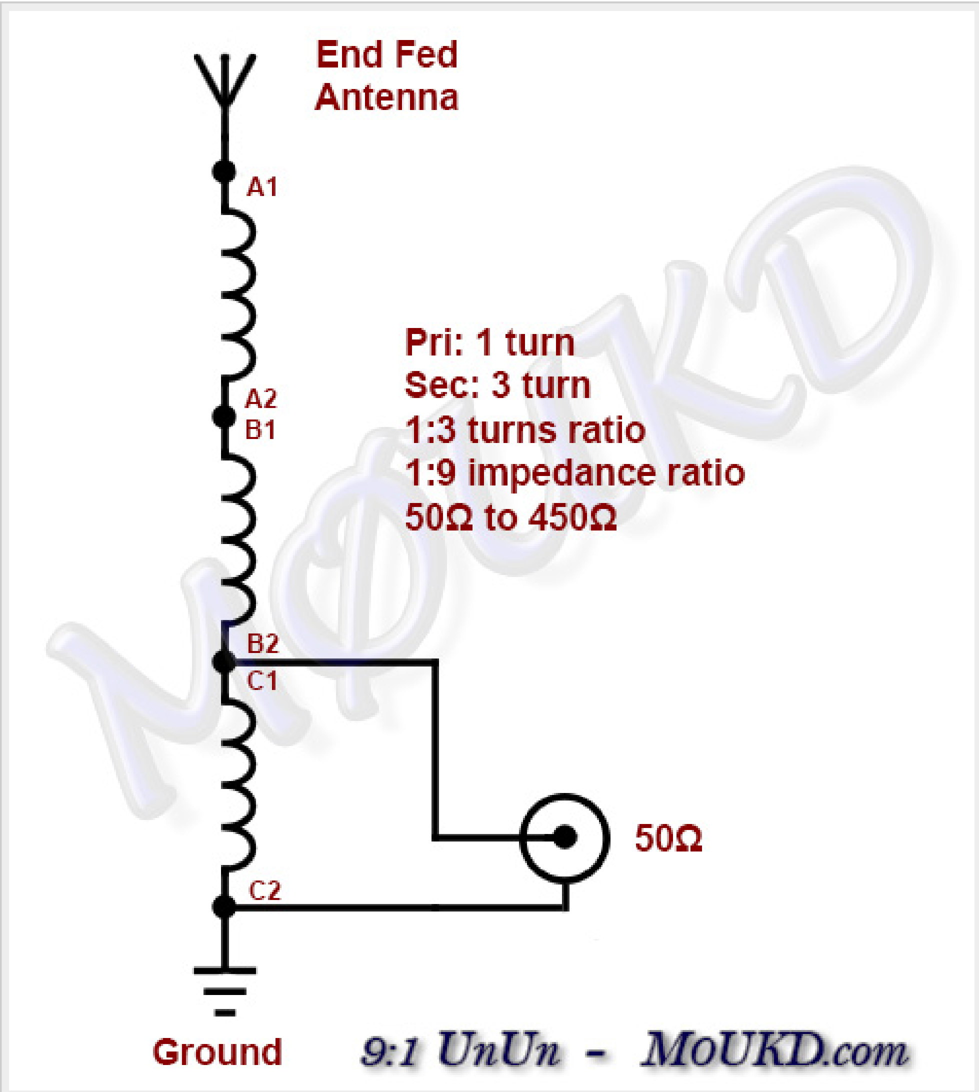
Pictures above showing driven element detail
with hairpin match attached and insulators mounted on boom

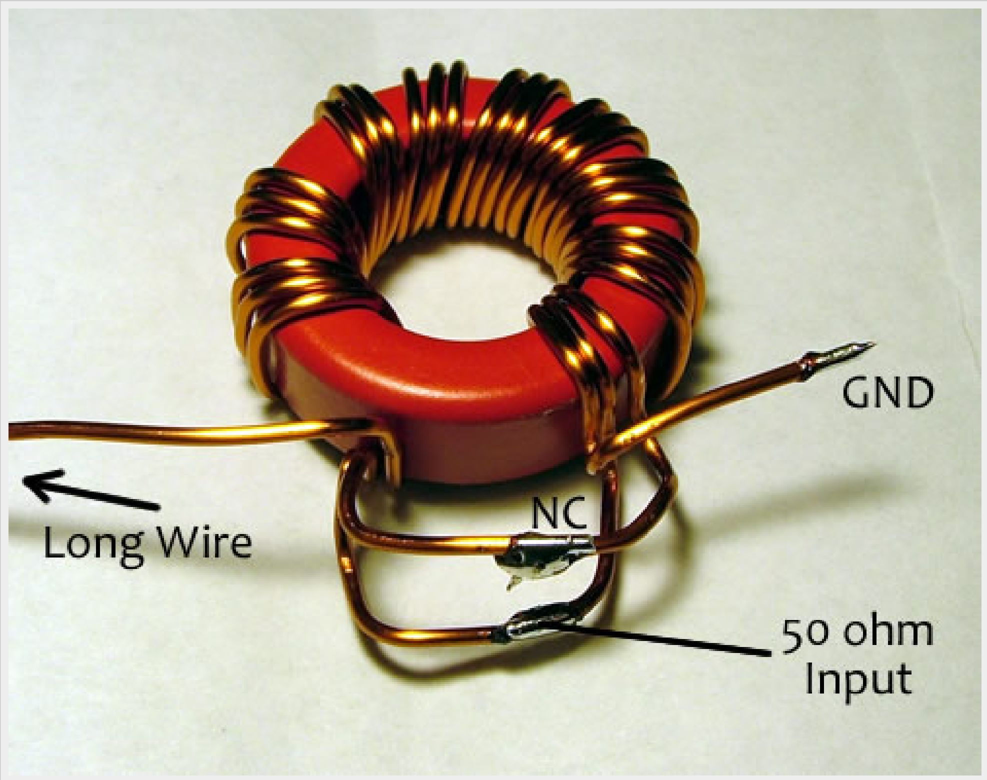
Many thanks to Russ, VE6VK for allowing us to share his project with all!
Russ not only is a fine antenna builder, ask him how to catch a fish!
Email Russ here for questions

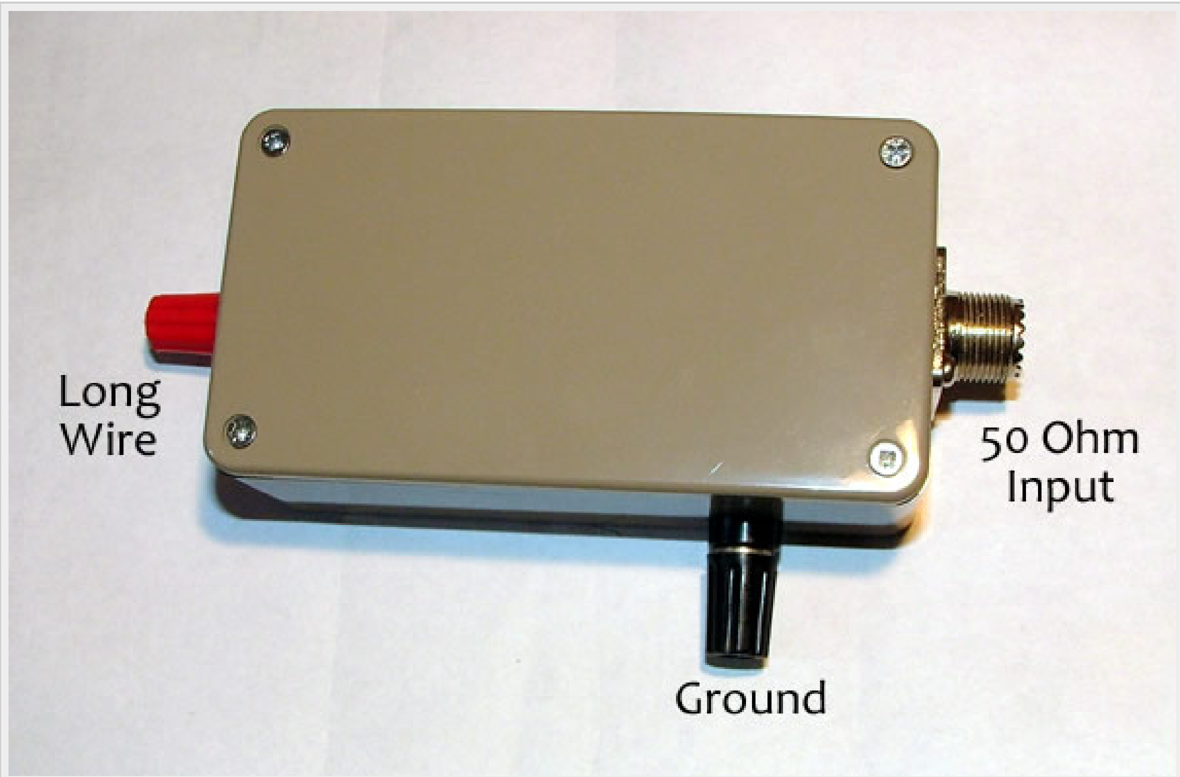
9:1 Magnetic Longwire Balun / Unun




450Ω
To Wire Antenna
A1
B1
C1
A2
Accept
C2
50Ω
To Radio
or Tuner
Ground Rod or
Counterpoise
9:1 UnUn - John MØUKD


End Fed
Antenna
A1
A2
B1
B2
C1
C2
Pri: 1 turn
Sec: 3 turn
1:3 turns ratio
1:9 impedance ratio
50Ω to 450Ω
50Ω
Ground
9:1 UnUn - M0UKD.com
MØUKD


GND
NC
Long Wire
50 ohm
Input

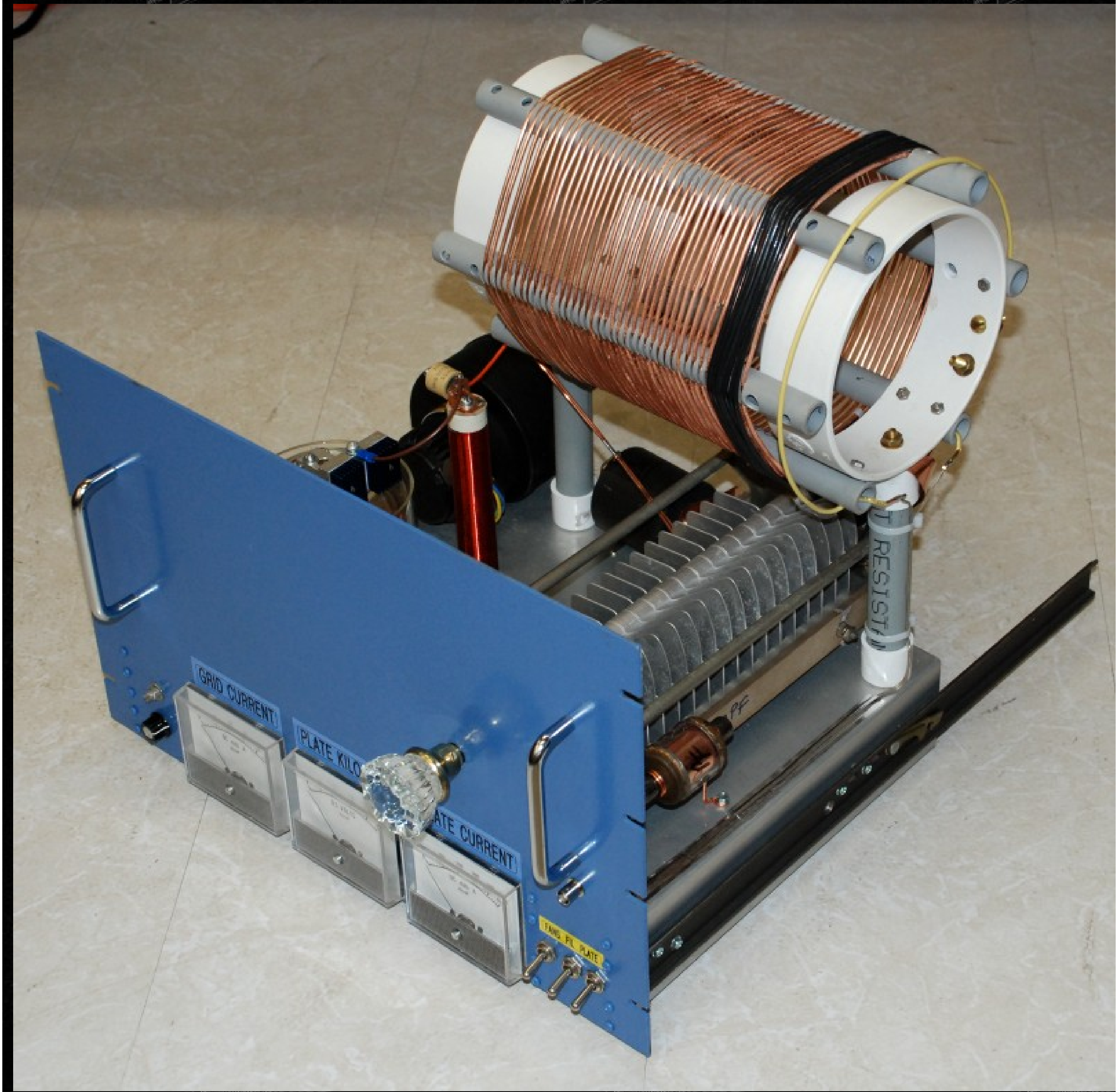

Long
Wire
50 Ohm
Input
Ground

A 500 Watt Output 4-400A Linear Amplifier for 600 Meters

By W5JGV - WD2XSH / 7

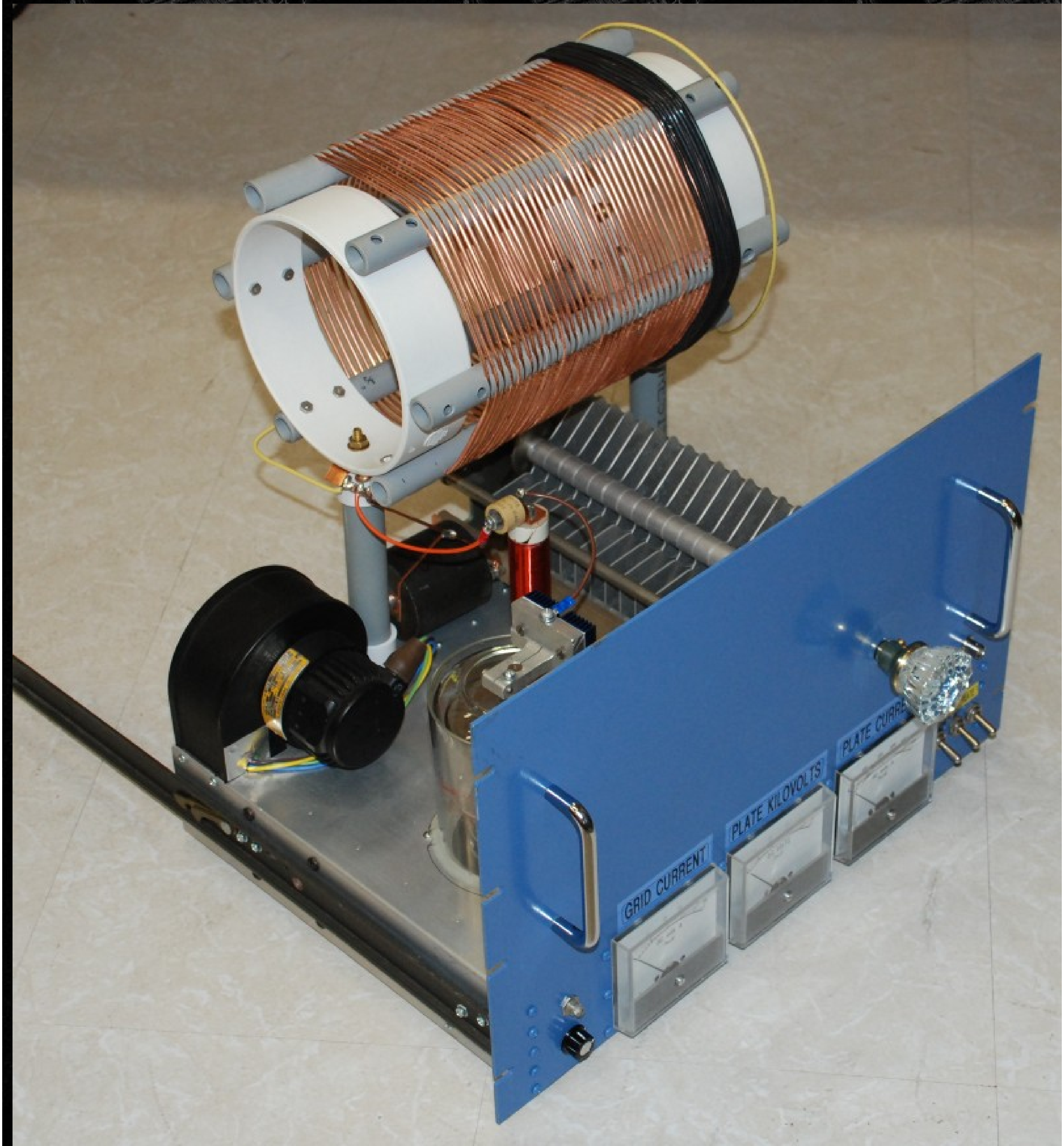
First Posted on December 14, 2008

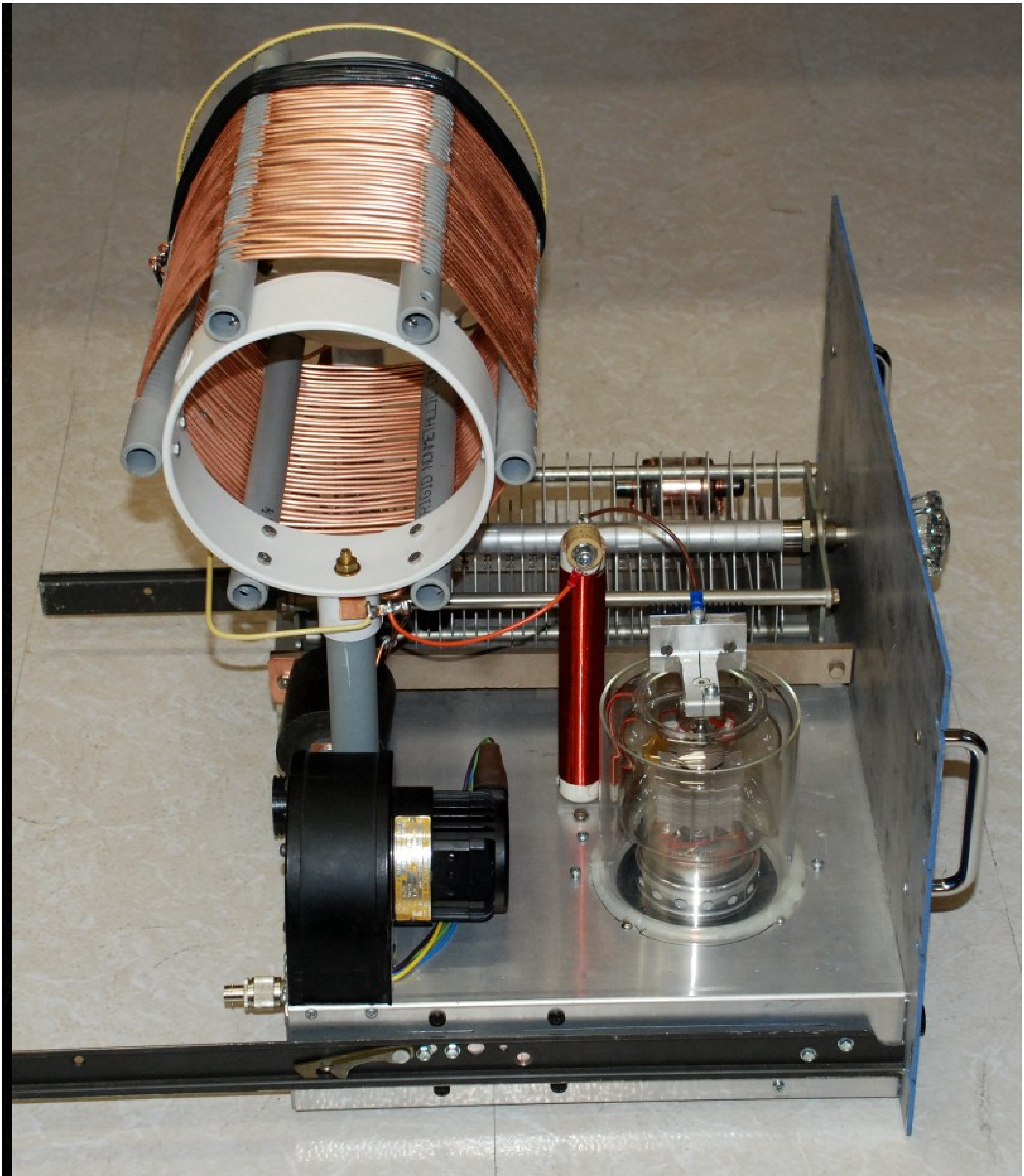
An Hybrid Amplifier Designed for the ARRL 600 Meter Research Project



This amplifier is capable of 500 watts of RF output in linear operation on the 600 meter band.

The RF drive requirement is less than 50 milliwatts.





With 3200 Volts on the anode, the amplifier draws 268 MA key down, CW mode. Screen voltage is 600, and the anode idle current is 80 MA. Idle dissipation is 256 watts. DC Input power is 915 watts, and the RF output power to the dummy load is 540 watts, for a calculated efficiency of 59% with good linearity.

In order to get more than a few miles on 600 Meters, it is necessary to use a fairly serious RF power amplifier to feed enough power to the typical antenna used on that band. Antenna efficiency normally will be in the range of 4 to 18 percent, unless the operator makes a heroic and expensive effort to install a really serious antenna. As a member of the ARRL 600 Meter Experimental Project, (WD2XSH/7), my proposed antenna will be in the low to middle point in that range, hence the need for some serious RF from the amplifier. Because the predominant digital mode to be used from this station will be PSK-31 it was necessary to use a linear amplifier in order to obtain a clean signal on the air.

Although I was able to successfully modify the solid-state linear amplifier that I had previously used on 166.5 KHz for experimental station WC2XSR/13 to enable it to operate on 600 Meters, I found the relative fragility of the transistors to be a problem. After vaporizing several of the MOSFET devices while attempting to operate the amplifier into a slightly mismatched load, I decided that perhaps I might be better off with a vacuum tube amplifier for at least the initial phases of testing. Since I had previously had some experience with designing and operating high power vacuum tube amplifiers, I reached into my Junk Box and started to build a new amplifier.

I already had the beginnings of an amplifier that I had planned to use for another medical research project. It was designed to operate in the 27 MHz ISM band, but due to changing requirements, I had never completed the amplifier. All that existed was the power supply and the amplifier chassis which contained a 4-250 tube, an RF choke for 27 MHz, a filament transformer, several meters, and the cooling system for the tube. I figured that this would make the start of a nice linear amplifier for the 600 Meter band.

Since I am retired and I did not want to spend a lot of money on the amplifier, I "made do" with a lot of odd parts and I used whatever I could find around the shack to build the amplifier. I left the 4-250 in place during the construction and initial tune-up tests, since the only real difference between the 4-250 and the 4-400A is the plate dissipation rating. All the interelectrode capacitances, grid voltages and drive requirements are the same for both tubes when operated at the same DC input power level. After construction was complete and all circuit constants had been determined, I replaced the 4-250 with the 4-400A and began full power tests.

Special thanks should be given here to N6LF, Rudy Severns, who graciously provided me with the 4-400A tube - and a spare - plus the sockets and the Eimac chimneys for the tubes. Also, my great thanks go to W5THT, Pat Hamel, who let me bounce lots of ideas off of him during construction.

To help you to quickly follow the circuit discussion in this article, please download the PDF files listed here.

You may wish to print the files for easier reference while reading this web page,

Click to download the Block Diagram of the amplifier.

Click to download the schematic diagram of the RF Driver.

Click to download the schematic diagram of the 4-400A PA.

Click to download the schematic diagram of the Bias Voltage Regulator.

Click to download the schematic diagram of the Power Supply.

Click to download the data sheet for the 4-400A.

Click to download the data sheet for the IRF730.

Click to download the data sheet for the 2N5089.

How it began...

I grew up (in a technical sense) just as transistors started to appear on the electronics scene. As a result, I feel comfortable working with either vacuum tubes or transistors for whatever project I am working on. After blowing up a few MOSFET's

in my solid-state amplifier, I decided that the design of that amplifier was pushing a two-transistor design right up to the limit, and any load or operating errors were going to result in destroyed devices pretty much no matter what I did. With that in mind, I started on the preliminary design of a new solid state amplifier that would use up to twenty MOSFET's arranged to share the load evenly. It "should" be bulletproof, and it would be capable of generating 1500 watts of RF.

After purchasing quite a few of the components for the new design, I came to my senses and realized that the actual implementation of the amplifier would likely be rather more difficult than the calculations indicated (personal experience speaking there!!) so I rethought the idea again. By then, I had recalculated the power budget for the antenna system and decided that about 500 watts of RF would be more than enough to accomplish what I needed to do. It was then that I thought about using the as yet unfinished 27 MHz amplifier.

Having executed a few designs with both solid-state and vacuum tubes, I thought that it might simplify the design of the amplifier if I were to use transistors for the low power portion of the amplifier and a vacuum tube for the output stage. I also knew that I would have to have considerable gain between the input to the amplifier and the output, because the RF drive available from the Starpoint channel modem I was using is quite low. I calculated the gain budget, and found that I could do the job with only two transistors. A single high power vacuum tube as the output amplifier would complete the design.

I knew that using a push-pull amplifier would result is a better output waveform with reduced even harmonics, and also make the amplifier more efficient. The problem was, that I had only one 4-250 available at that time, and the air cooling system was only able to provide enough air for one tube. I also felt that if I added a second tube, there might not be enough room on the rather small chassis (remember, this was for a 27 MHz amplifier) to fit the plate tank circuit. In addition, using a single tube would allow me to use a smaller tank coil and a single-section tuning capacitor for the tank circuit.

Enter the 4-400A. It was a drop-in fit for the 4-250, but would easily handle a Kilowatt DC plate input with a single tube. It would be necessary to operate the tube in the Class AB2 region to both obtain sufficient output power and reasonable linearity at the same time. I also knew that the tank circuit design would be trickier if good linearity was to be obtained.

GENERAL CIRCUIT CONFIGURATION

Please refer to the PDF of the Block Diagram of the amplifier.

RF drive is supplied to the amplifier by my Starpoint RF Channel Modem at a drive level of roughly 31 milliwatts @ 50 Ohms. A signal level of less than 50 milliwatts across a 50 Ohm resistor will be enough to drive the amplifier to full output. This is slightly more than 3.5 volts peak-to-peak. Any suitable source of 600 meter RF may be used instead of the Starpoint modem.

The first RF Driver stage uses a 2N5089 transistor to boost the input RF signal to a maximum level of about 10 volts. This amplified signal is sent to the gate of the second RF Driver stage, which uses an IRF730 MOSFET. This stage boosts the RF drive to the 5-watt level.

The 4-400A power amplifier stage is driven by the secondary of the RF driver output transformer that is driven by the IRF730. Both the primary and secondary of the transformer are tuned to resonance at the operating frequency to produce a clean drive waveform for the 4-400A

AC Mains power is supplied to the Main Power Supply, which is remotely controlled from the amplifier chassis by several front panel switches. Mains AC from the main power supply passes through to the amplifier chassis, where it is fed to the filament transformer for the 4-400A, the blower that cools the tube, and the +41 volt power supply for the RF driver board.

The Main Power Supply produces the required voltages for the 4-400A. They are: +3200 volts for the anode; regulated +600 volts for the screen grid; and -150 volts for the grid voltage regulator for the grid 1 bias.

RF DRIVER BOARD

Please refer to the PDF of the RF Driver.

The input to the first stage in the RF Driver amplifier is shown terminated with a 3300 Ohm resistor. This is because of the low level RF signal available from the Starpoint channel modem I am using. This resistor may be changed to any convenient value between 50 to 4700 Ohms, depending of the drive signal available. It is recommended that the

terminating resistor not be omitted as this may cause the first driver amplifier to go into oscillation under low drive level conditions.

The 2N5089 is operated in Class A. Negative feedback is provided by the 680 Ohm resistor in the emitter lead. The 2.5 Kohm RF Gain control acts as a high frequency bypass across the 680 Ohm resistor, and increases the gain of the 2N5089 as the resistance of the potentiometer is reduced. This adjustment will normally be set to about 50% of rotation.

The amplified drive signal is taken from the collector of the first stage through the 0.0022 uF DC blocking capacitor and fed to the gate of the IRF730 MOSFET. DC Bias for the IRF730 is provided by the 120 Kohm resistor and the 20 Kohm potentiometer. The 33 Kohm resistor between the wiper of the Bias pot and the gate of the IRF730 isolates the RF drive from the DC bias line. NOTE: If the +41 volt power supply does not current limit at about 2 amperes, it is possible to destroy the IRF730 if you set the Bias pot too high.

Output Transformer T1 serves a dual purpose, It resonates at the 600 Meter frequency of operation, and it steps up the 41 volt drain voltage waveform to approximately 300 volts maximum peak voltage to drive the grid of the 4-400A. The primary of T1 is brought close to resonance by the use of a 6800 pF poly film or mica capacitor. The secondary is tuned to resonance by using a combination of variable and fixed capacitors.

To adjust the driver amplifier for best performance, Insert the 4-400A (or a 4-250) in the socket. Apply filament voltage, grid 1 bias, and cooling air to the tube. Do NOT apply screen voltage or plate voltage!

Prepare to feed the input of the driver amplifier with an adjustable level two-tone RF drive signal that measures about 3 Volts peak-to-peak at maximum level as measured on an oscilloscope. For now, set the drive level to about 0.5 volts.

Turn the RF Gain pot to MAXIMUM resistance. (Lowest RF Gain.)

Set the IRF730 Bias pot to minimum bias - that's with the wiper set to the ground end of the pot.

Apply power to the RF driver amplifier board. No smoke? Good!

Using the oscilloscope, observe the waveform at the collector of the 2N5089. It should be a sine wave with very little distortion. If it is clipping, reduce the RF drive level.

Adjust the RF drive level to the point where the signal the the collector of the 2N5089 just starts to clip. Then, reduce the signal to 60 - 75% of that value,

Connect one channel of the oscilloscope to the RF input of the driver amplifier, and another oscilloscope channel to the grid of the 4-400A.

Increase the RF drive level while observing the oscilloscope waveforms. Stop increasing the RF drive below the point where the grid waveform clips or distorts badly.

Adjust the tuning capacitor across the secondary of the driver transformer for the best waveform. What you want to do is to adjust everything to get the two-tone grid waveform envelope to match the exact shape of the RF Driver input two-tone waveform envelope.

You will see lots of distortion at the crossover points of the two-tone signal. Increase the bias on the IRF730 to eliminate the crossover distortion. As you increase the bias, the gain will increase, so you will need to reduce the RF drive level to prevent peak distortion.

"Play with" the input RF drive level, the adjustment of the IRF730 Bias, the RF Gain and the T1 secondary tuning capacitor to get the envelopes of the waveforms to match. It is not necessary to have the grid current meter read more than 25 MA during these adjustments, as that will be plenty of drive for full power. The first time I attempted to adjust the driver amplifier, it took me about an hour to "get the hang of it." After that, I was able to readjust the amplifier within a few minutes after making component changes during testing.

You may need to adjust the value of the 6800 pF capacitor that is placed across the primary of transformer T1 in order to improve the waveform. Although this value if not critical, it is important. Correct selection of this capacitor will keep the drain current minimized and allow the driver amplifier to produce more power output.

After completing the adjustment as described here, note the accuracy of the waveform envelopes and how close they match. Take a digital photograph is you can. Now, reverse the leads from the secondary winding of transformer T1 . Repeat the adjustments and compare the waveform accuracy with the results you achieved before you swapped the leads from T1. Leave the leads from T1 connected which ever way gives the best and most accurate waveform envelope.

GRID BIAS REGULATOR

Please refer to the PDF of the Bias Regulator.

The function of the grid bias regulator is to hold the grid bias constant when grid current flows and to allow the bias to be adjusted for the correct voltage to set the no-signal idle plate current through the 4-400A and to reduce distortion and improve amplifier linearity through the 4-400A. In this design, a resting idle current of about 80 MA was sufficient to provide good linearity, as seen my the waveform photos later in this article.

The main power supply generates a regulated -150 volts from a VR-150 regulator tube. This voltage passes through a 100 Kohm resistor located in the power supply and then on through the connecting cable to the bias regulator located in the RF amplifier chassis. The bias regulator is a single stage shunt regulator. The IRF730 MOSFET acts as a variable resistor between the bias voltage line and ground, and allows the operator to adjust the negative grid bias voltage to any desired value between -40 to -130 volts. When grid current flows, the electrons collected by the control grid of the 4-400A would cause the negative bias voltage to increase, but the IRF730 "wants" to hold the voltage constant. It shunts the extra electrons to ground, thereby holding the grid bias constant.

It is important to understand that the power supply feeding the bias regulator must have a limited amount of current available. The simplest way to limit the available current is to place a resistor in series with the output of the power supply feeding the Bias Regulator. Attempting to connect the bias regulator to a "stiff" power supply will cause the IRF730 to draw excessive current. This will damage the power supply or destroy the IRF730, or both.

In this circuit, the 100 Kohm resistor limits the available current to approximately 400 V / 100000 Ohms = 0.004 A or 4 Milliamperes. This is just enough to "fire" the VR tube so it will regulate at -150 volts. At that point, the IRF730 need only shunt less than 4 MA to ground in order to set the bias voltage to the proper value. The only real function of the VR-150 is to place an upper limit on the bias voltage when the IRF730 is biased off by the use of the Cut Off Bias Relay contacts. When grid current flows during normal grid drive conditions, the current the IRF730 shunts to ground will increase, but in any case it will be no more than the operating grid current plus the current through the 100 Kohm resistor. This will be something less than a total of about 40 MA.

The bias voltage is set by adjusting the 10 Kohm potentiometer. Note that this is an "upside down" circuit, that is, the positive side of the power supply is grounded. That's handy for this circuit, since it allows us to simply bolt the IRF730 directly to the grounded chassis with no insulators being required. In any case, the transistor does not get very warm, since it only has to dissipate a few watts at most.

The Cut Off Bias Relay switch shown in the diagram is operated by a switch at the operators position. When the switch is opened, the IRF730 is turned off, and that allows the grid bias to increase to the full -150 volts supplied by the main power supply. This cuts off all plate current flow through the 4-400A, preventing the tube from generating any shot noise that would desensitize the receiver.

Because this is a single transistor regulator, it does not have much gain. It holds the grid bias to within about 2% of the set point, which is adequate. Because of the low gain, there is some "bounce" on speech waveforms. The addition of the 1 uF capacitor from the bias line to ground eliminates most of this bounce. This capacitor may be increased in value if additional bias smoothing is required.

4-400A POWER AMPLIFIER

Please refer to the PDF of the 4-400A PA.

RF drive for the 4-400A comes from the RF Driver output transformer, shown here as transformer T1. One end of the secondary winding of T1 is connected to the output of the bias regulator through the 25 MA grid current meter. RF bypassing to ground is provided by a pair of 0.47 uF and 0.01 uF capacitors.

Screen voltage comes directly from the screen voltage regulator in the main power supply. No metering for the screen current is provided since the current is limited to 80 MA by the series dropping resistors in the main power supply. If the screen attempts to draw more than 80 MA, the screen voltage will drop proportionally, thereby limiting the power dissipation of the screen to a safe value.

This arrangement is not the best use of the VR tubes because during periods when the plate current is cut off, such as during receive, the full current available through the screen dropping resistors must pass through the VR tubes. These tubes are rated for operation at 30 MA, and they will be subjected to an overload condition because 80 MA will pass through them. However, since plate voltage will normally be turned off during receive periods, the current will rapidly decrease as the filter capacitors discharge. A better arrangement would be to use either a solid-state regulator that can handle the extra current or to use a relay to place a resistor across the VR tubes to shunt the extra current away from the VR tubes during receive.

The filament of the 4-400A is fed by a step-down transformer. RF bypassing of the cathode to ground is done with multiple ceramic disk capacitors. The center tap of the filament transformer connects to a 500 MA meter that reads cathode current and screen currents. Although this gives slightly high readings for the plate current, placing the meter in the cathode circuit greatly reduced the shock hazard that would be present if the meter were to be placed in the plate high voltage line.

The cathode current meter is bypassed by a 0.51 Ohm resistor and a 1N4001 diode. Should there be an arc inside the 4-400A, the sudden increase in cathode current will cause a large voltage drop across the meter movement. This could be high enough to burn it out, or at least wrap the needle around the pin. If more than one ampere flows through the circuit, this will cause the voltage across the meter movement and the resistor to exceed the conduction potential of the 1N4001. The diode will then conduct and act as a voltage limiter, shunting excess current around the meter. Should an arc event happen, the overcurrent relay in the main power supply will interrupt the mains power to the HV supply promptly to prevent serious damage.

Plate voltage to the 4-400A is supplied through the 1.65 MHy RF Choke. A DC blocking capacitor of 1000 pF allows the RF from the anode of the tube to go to the plate tank circuit. Because a single variable capacitor of the size needed to tune the tank circuit to resonance would be quite large, a combination of variable and fixed capacitors were used in the amplifier.

The RF Output coupling link coil is fixed in place for simplicity. Loading adjustment is provided by the use of a separate tap on every turn. If it is needed, an additional fine loading adjustment may be accomplished by the use of a large variable capacitor in series with the output of the link coil. See most early editions of the *Radio Amateurs' Handbook* for more information.

While building the amplifier, I quickly found out that a few things must be considered to get good performance out of the amplifier when running in a linear mode. First, the control grid bias supply must be stable and noise free. Second, the screen voltage supply has to be really well regulated or the linearity will suffer badly. I used VR tubes, because they were available and generally work well enough. I did find that the 30 MA that they can supply in regulated mode was not enough for the amplifier. I had to adjust the resistor value feeding the VR tubes to allow almost 80 MA of current at full load. This is excessive for the VR tubes, but the screen normally pulls enough current so that the VR tubes are not overloaded. During each RF cycle in the tank circuit, if the plate voltage drops below the screen voltage, the screen will draw enough current to cause the screen voltage to go out of regulation. This will cause severe distortion in the RF output of the amplifier.

Another thing I found is that the plate tank circuit must have much more capacity that calculations would indicate. In fact, at least twice the calculated value. If the "C" is too low, the amplifier will not be able to generate very much power with good linearity. When loading the amplifier, it should be loaded quite heavily for best linearity. In fact, at correct load, there is almost no plate current dip visible on the cathode current meter at resonance. At light load, of course, there is a pronounced plate current dip at resonance.

MAIN POWER SUPPLY

Please refer to the PDF of the Power Supply.

The main power supply converts the mains AC voltage to the voltages needed for the 4-400A. Since the power supply was originally designed for use as a test system for a research project, it was built with flexibility in mind. It has been modified slightly to use with this amplifier, so you will see some differences between the description , diagrams and the photos in

this article. There is nothing special about this power supply, and any suitable supply providing these voltages may be used with this amplifier.

The high voltage plate transformer was salvaged from a very early microwave oven. This particular transformer weighs almost 20 pounds, and has a lot of iron and copper in it when compared to most present day microwave oven transformers. Because of the extra iron in the core of the transformer, I was able to boost the AC input voltage to the transformer to increase the secondary voltage by about twenty percent. If you try that trick on most of these transformers, they will draw way too much primary excitation current and overheat badly. This transformer was not bothered by the voltage increase because it is a "real" transformer, and not a "toy" transformer that uses the minimum amount of copper and iron.

The output of the HV transformer is full wave bridge rectified and sent to a bank of 16 series connected capacitors, each of which is rated at 2900 uF at 200 VDC. This is the equivalent of 181 uF @ 3200 VDC. Do NOT get your fingers across this thing when it's powered up! Because the supply was designed to have an output of 2500 to 2700 volts under load, the capacitors are operated slightly above their ratings in this application. When in use with the boosted AC mains voltage, the capacitors are charged to between 2700 to 3700 volts depending on the load. There have been no failures - so far!

Each capacitor has a voltage equalizing resistor shunted across it. The negative lead from the capacitor bank is connected to circuit ground through a 5 Ohm resistor. The voltage drop across the 5 Ohm resistor is monitored by a small DC relay that pulls in if the supply current exceeds one Ampere. The power supply is then shut down and locked out until all power is removed and restored.

Screen voltage for the amplifier is obtained by a series of dropping resistors that are connected to 4 series-connected VR-150 voltage regulator tubes. The resistors limit the maximum short circuit current to a low enough level so that the screen grid cannot be damaged during normal operation or circuit malfunctions. Since the screen voltage is derived from the plate voltage supply, it is impossible to apply screen voltage without plate voltage at the same time. The resistors limit the maximum current flow to about 80 MA.

This arrangement is not the best use of the VR tubes because during periods when the plate current is cut off, such as during receive, the full current available through the screen dropping resistors must pass through the VR tubes. These tubes are rated for operation at 30 MA, and they will be subjected to an overload condition because 80 MA will pass through them. However, since plate voltage will normally be turned off during receive periods, the current will rapidly decrease as the filter capacitors discharge. A better arrangement would be to use either a solid-state regulator that can handle the extra current or to use a relay to place a resistor across the VR tubes to shunt the extra current away from the VR tubes during receive.

Grid 1 bias for the 4-400A is provided by a full wave rectifier that is fed by a separate transformer which is energized as soon as the filament voltage is turned on. The transformer is rated at 600 volts center tapped. This voltage, after rectification and filtering, results in a raw bias voltage of about -450 volts. This is much more than is needed, but the original design of the power supply allowed for producing bias voltages of up to -350 volts. The regulator circuit was changed to produce the lower bias voltage for this amplifier, but due to the difficulty of changing the bias supply transformer, the original transformer was left in place.

A step-start circuit is used in the primary circuit of the HV transformer to prevent start up inrush current surges. Due to the large excitation current normally drawn by the microwave oven transformer (which was increased even further by the boosted mains voltage) a power factor compensation capacitor was added to the mains circuit. This would be unnecessary if a real plate transformer were used.

The operational sequence of the power supply is controlled by a series of 12 volt DC relays. A small transformer and bridge rectifier supply the necessary DC control voltage whenever the mains voltage is connected to the power supply. Fuses are used for throughout the power supply for circuit and operator protection, and the entire supply is cooled by the use of a fan salvaged from an old microwave oven.

The operational logic of the control relays will be left as an exercise for the reader.

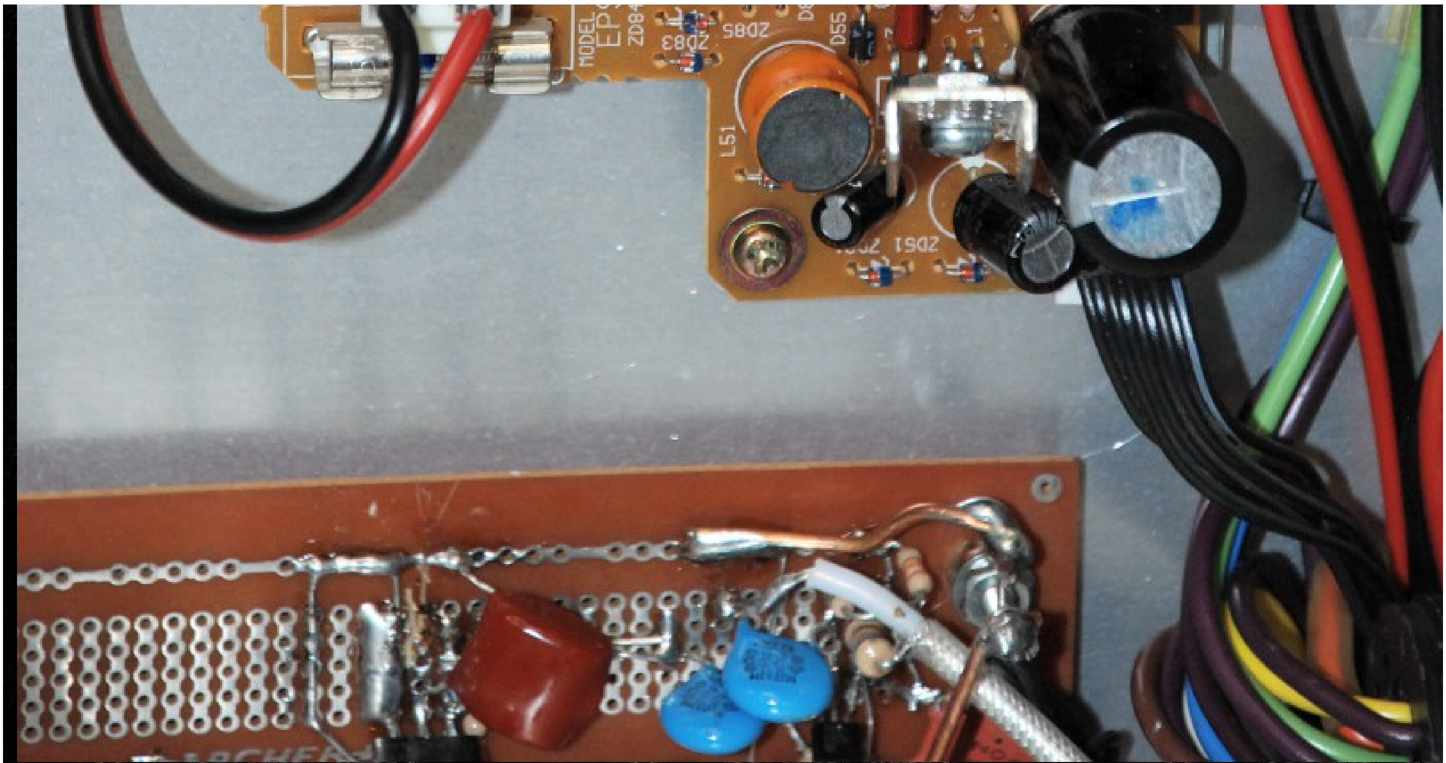
Now I'll take you through a look at the insides of the amplifier and point out a few of the construction details.

Under chassis view of the amplifier deck.

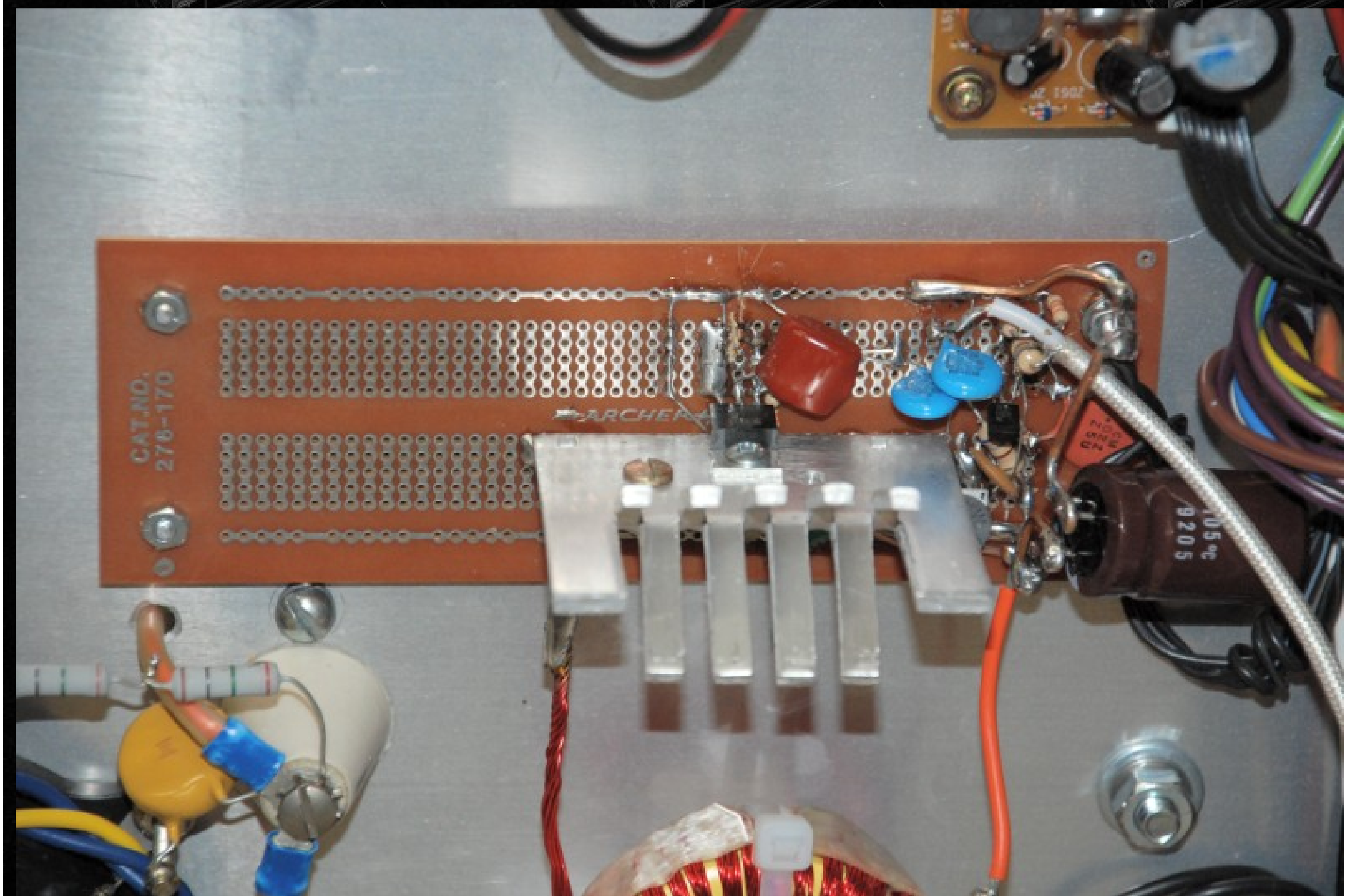
The front panel of the amplifier is to the left in this photo. The back of the three panel meters are seen at the left of the chassis. To the upper right is the +41 volt power supply for the RF Driver circuit board, which is seen mounted horizontally just below the power supply board. The power supply was salvaged from a discarded Epson inkjet printer. The supply puts out a regulated +41 volts and is current limited at 2 Amperes.

To avoid distortion and ripple in the RF signal, this power supply must be well regulated and filtered. Hum and noise on the +41 volt line measures less than 200 millivolts peak-to-peak. It is very important that the power supply for the driver stage is well regulated and filtered. Any hum or noise present in the power will AM modulate the RF signal and be present in the RF output from the amplifier.

The RF Driver output transformer may be seen just below the RF Driver board, and just above the filament transformer. The black square to the right of the filament transformer is the opening from the centrifugal blower that provides cooling air to the 4-400A tube. The white capacitor to the left of the filament transformer is the phasing capacitor for the split phase, capacitor-run blower motor. The tuning capacitor for the secondary of the RF driver output transformer may be seen mounted on the front panel at the bottom left of the picture.



The +41 Volt RF Driver power supply board.



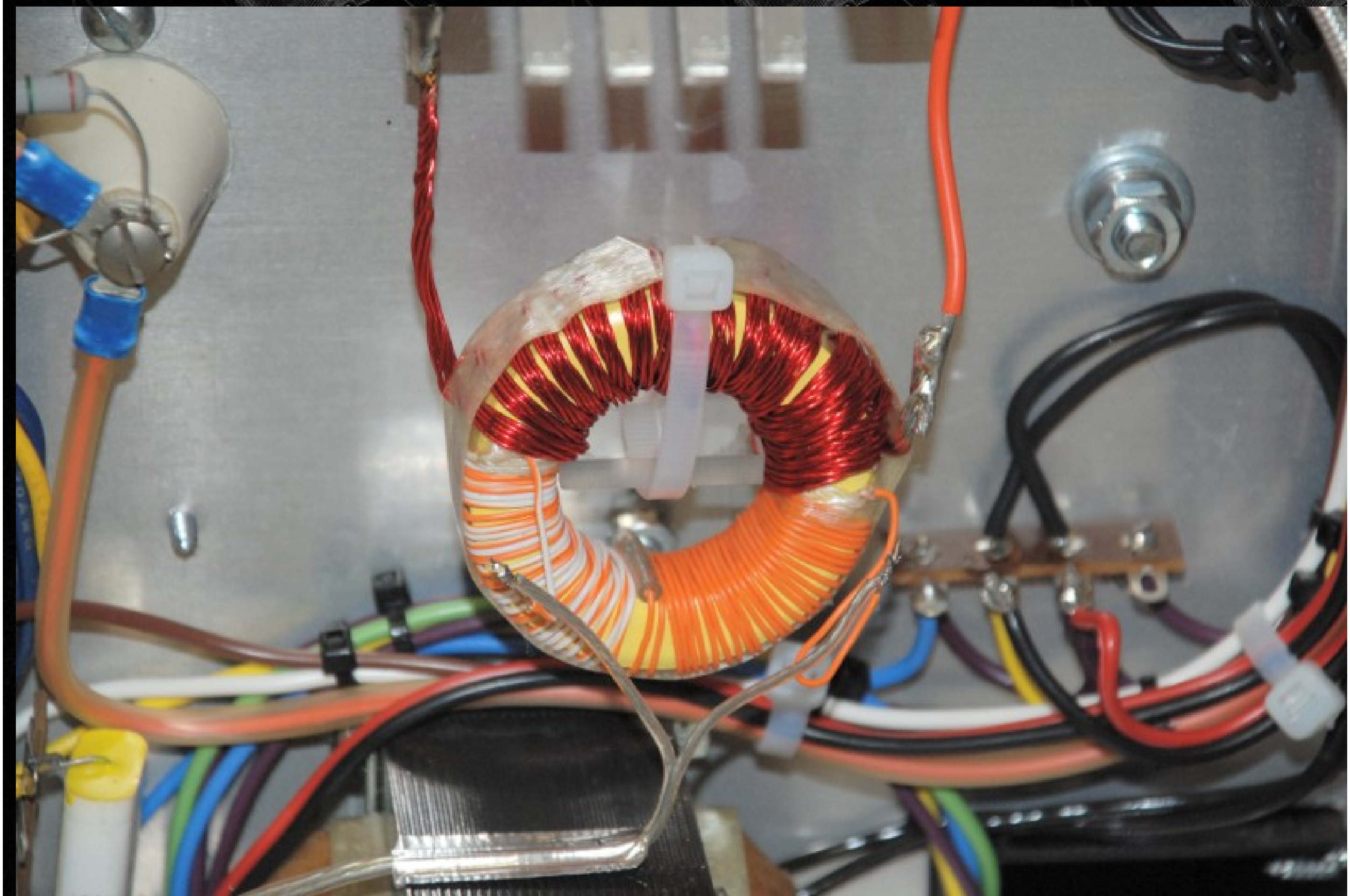
The RF Driver board.

Note the terrible construction practices and "blobby" soldering. It was built as a quick prototype, but it worked so well that I just stuffed it into the amplifier and called it finished!

The heat sink for the IRF730 was salvaged from an old computer power supply. It receives additional cooling from the air provided by the blower for the 4-400A. If the driver amplifier were to be mounted outside of the sir flow, a better heat sink would be required to prevent the transistor from overheating.

I had to add an extra low-ESR electrolytic capacitor directly across the amplifier power buss to reduce power supply ripple to the required low value. All of the capacitors you see in the picture were salvaged from old computer power supplies.

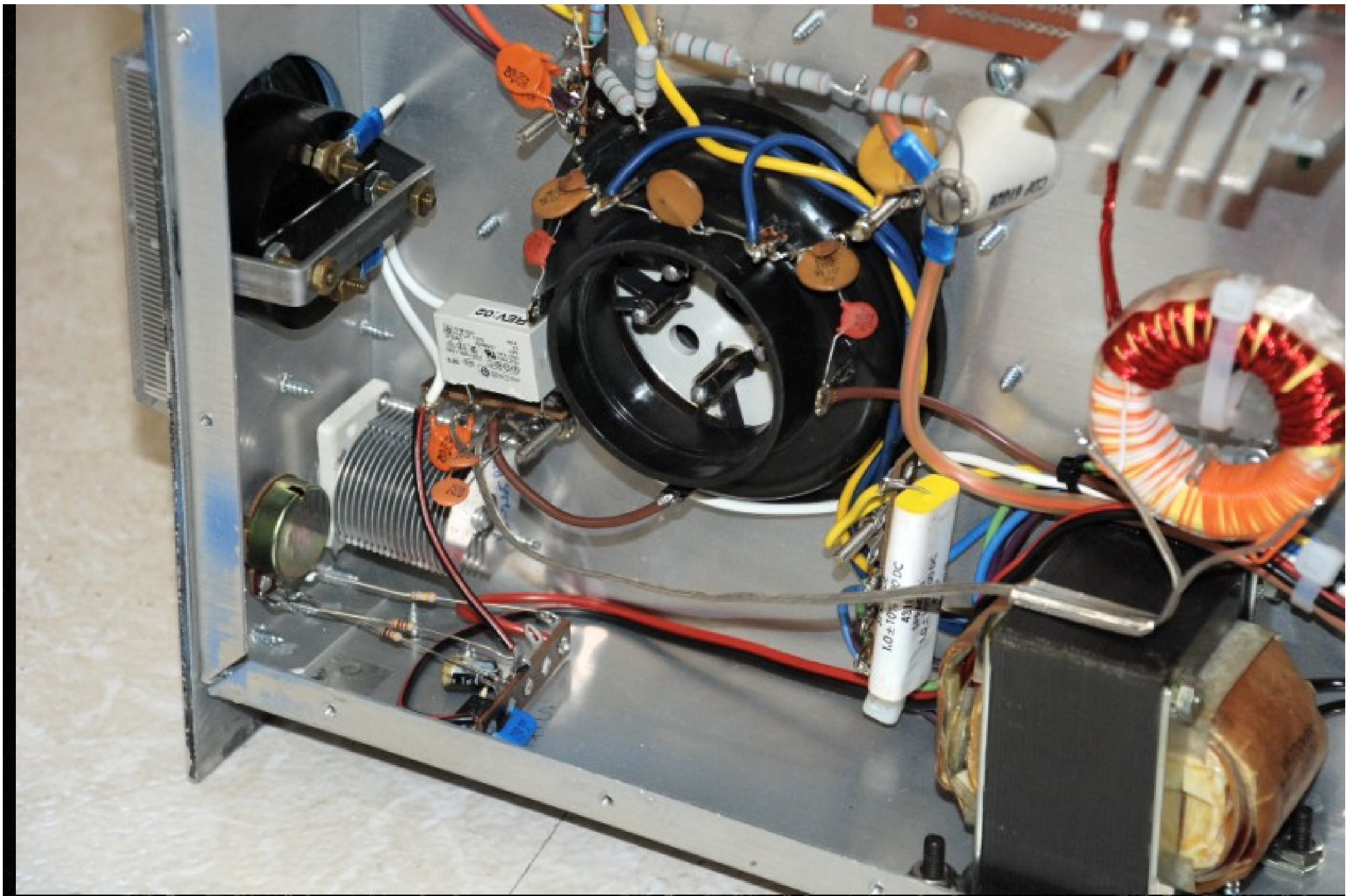
The square brown capacitor seen above the IRF730 is the tuning capacitor for the primary of the output transformer.



The RF Driver Output Transformer

The transformer was wound with 18 turns consisting of seven parallel twisted together strands of #24 AWG enameled wire for the primary. The wire for the primary was salvaged from a scrapped computer power supply switching transformer. The secondary is wound with a total of 50 turns fashioned from two lengths (connected in series) of #26 AWG wire from some scrap CAT-5 network cable. A single length of wire would have worked just as well, I simply did not have a long enough length of wire handy, so I connected two shorter lengths together for the secondary winding. The transformer core is a T-200-26.

Notice the use of a length of loudspeaker "Zip Cord" wire as the transmission line between the secondary of the driver output transformer and the grid of the 4-400A. It works very well, and no feedback or oscillations were noted in the amplifier under any operating conditions.

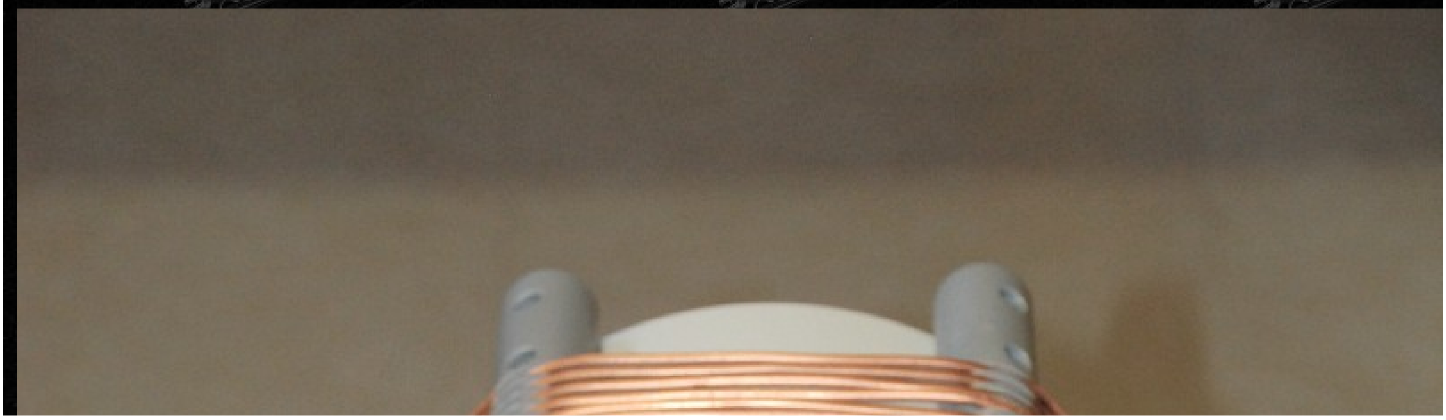


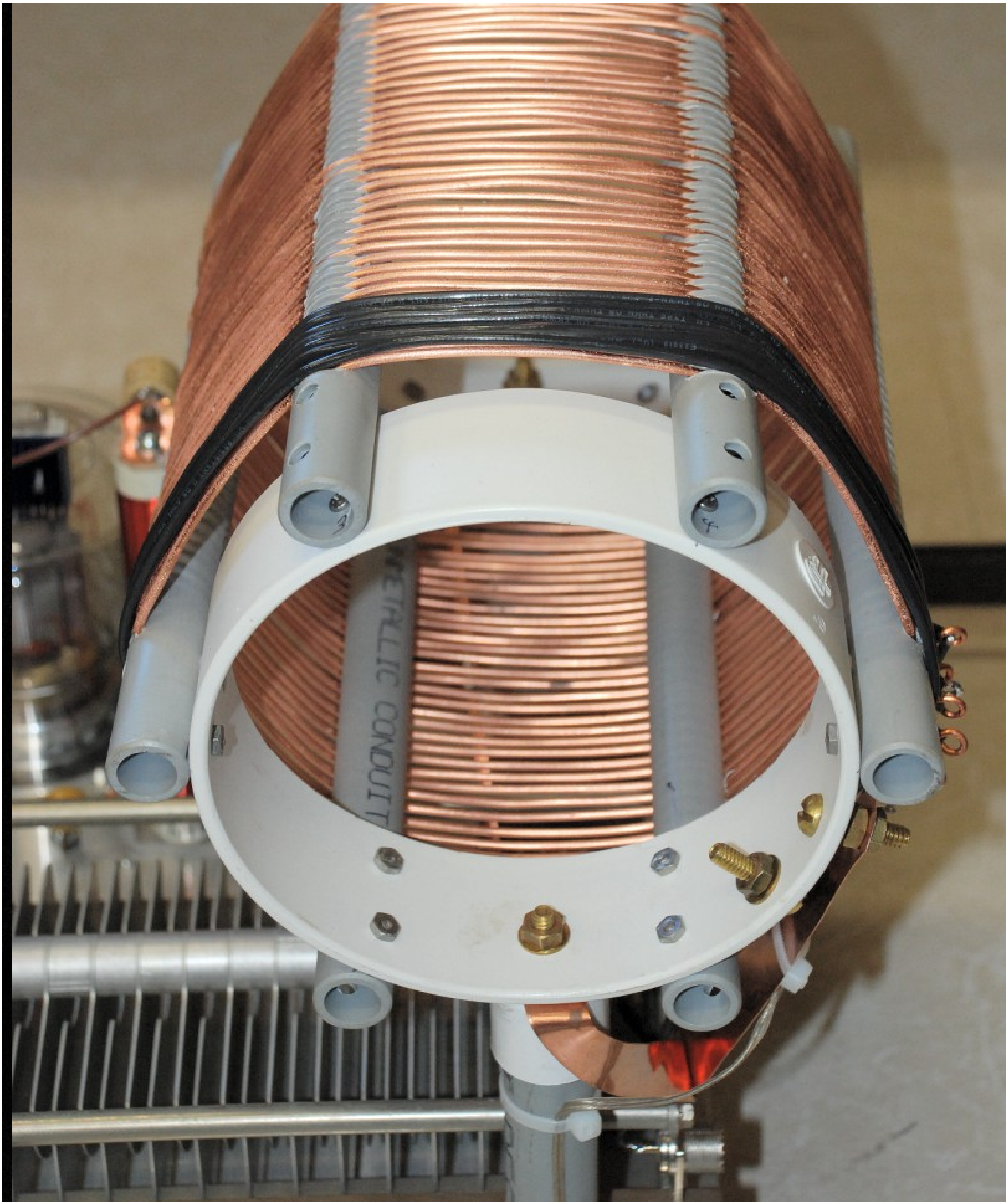
Grid Drive and Bias area.

The variable capacitor is the tuning capacitor for the secondary of the RF Driver output transformer. Because this capacitor is not adjusted very often, it has a screwdriver slot adjustment instead of a knob.

The two small brown disk capacitors at the right side of the variable capacitor are the fixed capacitors of 470 and 330 pF that are placed in parallel with the variable capacitor. Since the adjustment of the variable capacitor is not changed after initial adjustment, if desired, it may be replaced with a fixed capacitor after the final value is determined. Because the RF grid voltage and current is fairly low, I was able to use standard 600 volt disk bypass capacitors here.

The large white block-looking capacitor (which was salvaged from a computer power supply) seen above the variable capacitor, is the 1 uF grid voltage bypass capacitor. The actual grid bias regulator circuit is connected to the brown terminal strip mounted on the side wall of the chassis just below the tuning capacitor in this picture. The back of the grid bias adjustment potentiometer is seen in the left side bottom of the picture, next to the tuning capacitor.





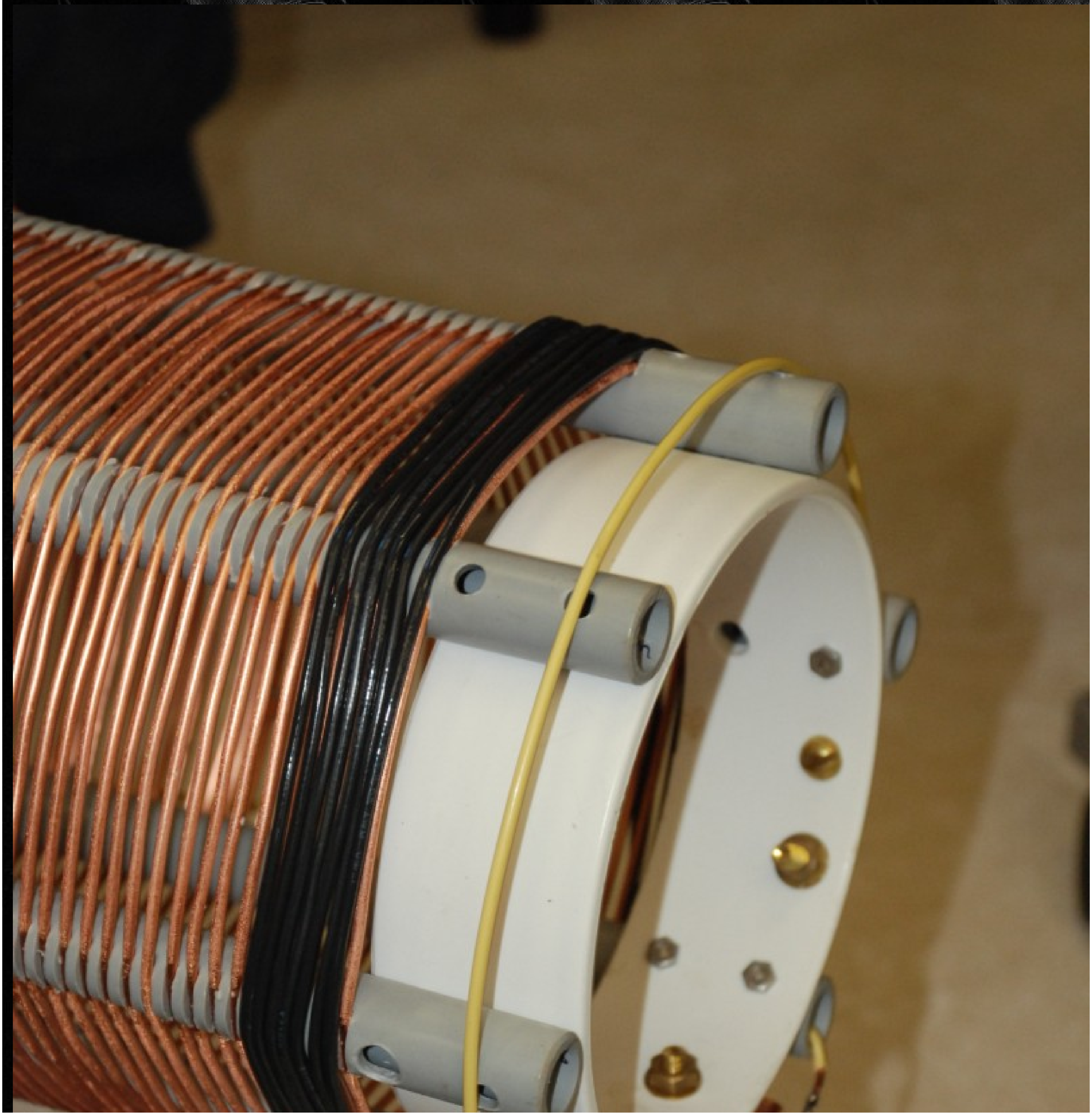
RF Amplifier Plate Tank Coil

This end view shows the general construction of the coil. The gray PVC support pipes have a series of slots about 1/4" deep that were cut into them by using a table saw. The wire for the coil is bare #10 AWG copper wire. After winding the

coil, I used some clear spray paint to coat the coil to keep the copper wire shiny looking. I forgot to stretch the wire before I wound it, and is sure shows! Brass hardware was used for all the RF connections. All other hardware was kept as small as possible to reduce RF Losses.

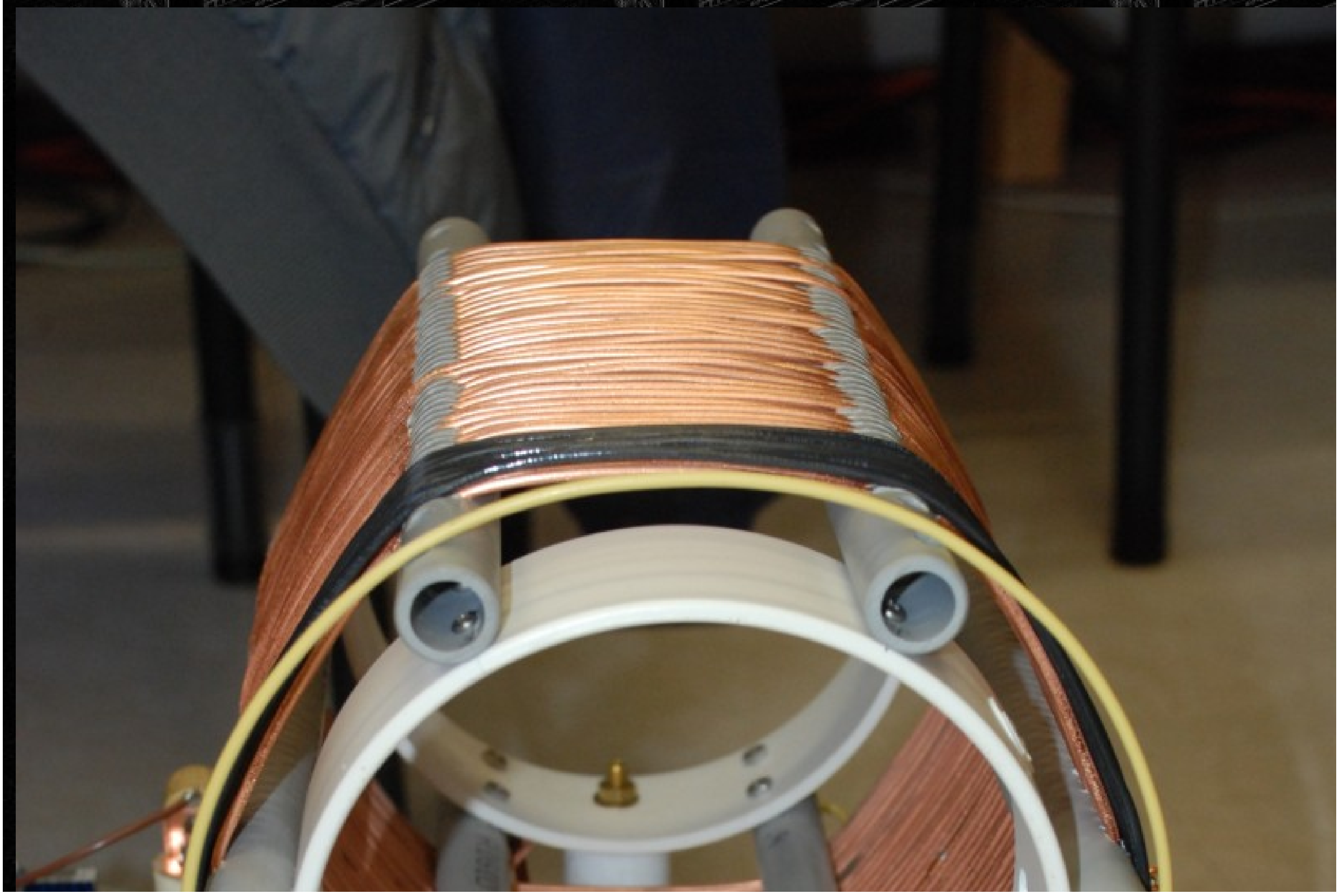
This coil was originally intended to be part of a loading coil variometer, and had a rotating link coil installed inside of it. However, it did not work out as planned, so I removed the link coil and used the fixed coil for the amplifiers' plate tank coil. As it finally worked out, the inductance was excessive, and so the completed amplifier only uses about half of the turns you see in the pictures.

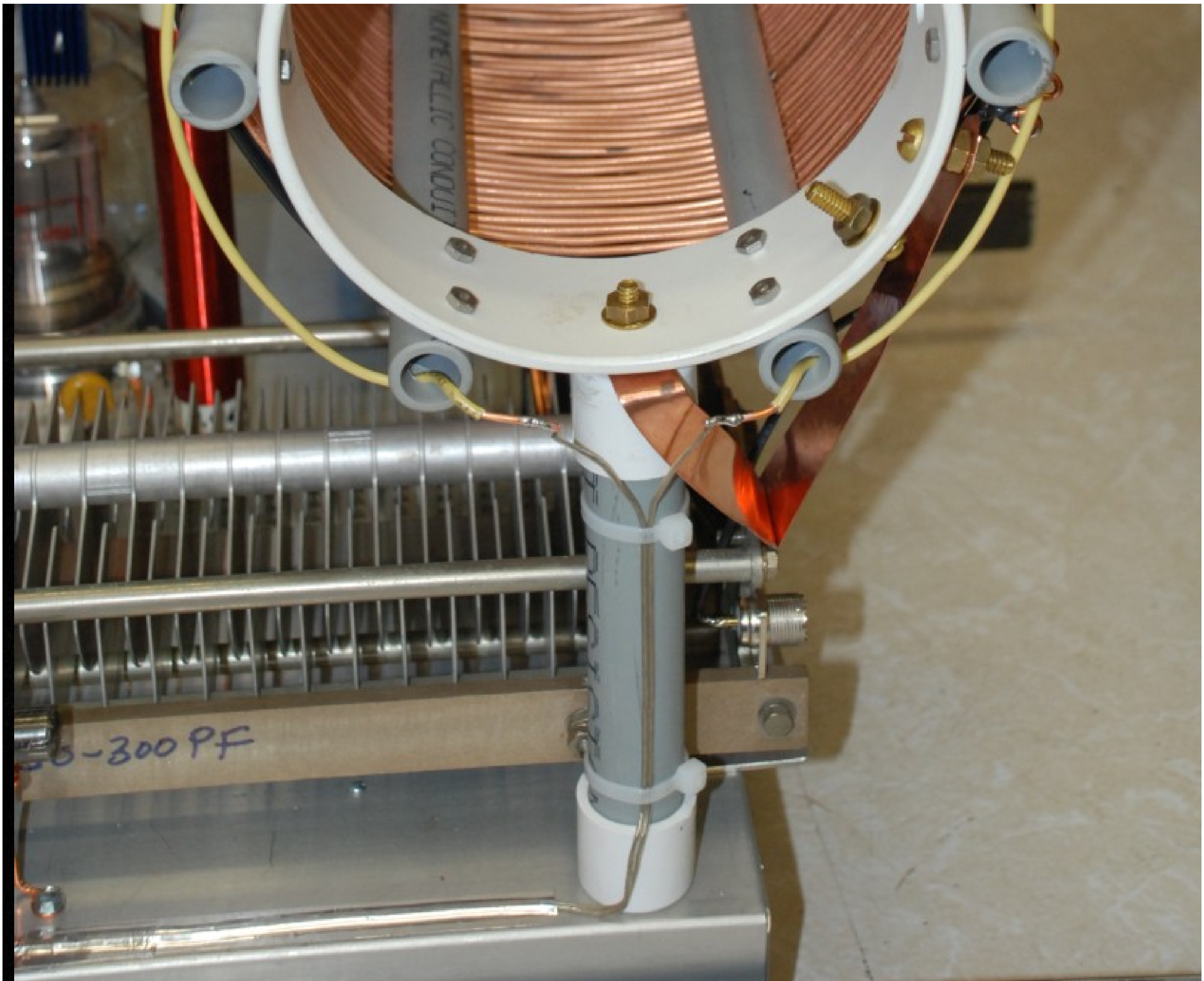
As you can see, the link coil was simply wound over the "cold" end of the tank coil. Taps were provided on evert turn for coupling adjusted. This may not look too neat, but it works very well and is stable in operation. The link coil was wound with #12 AWG THHN insulated copper wire.



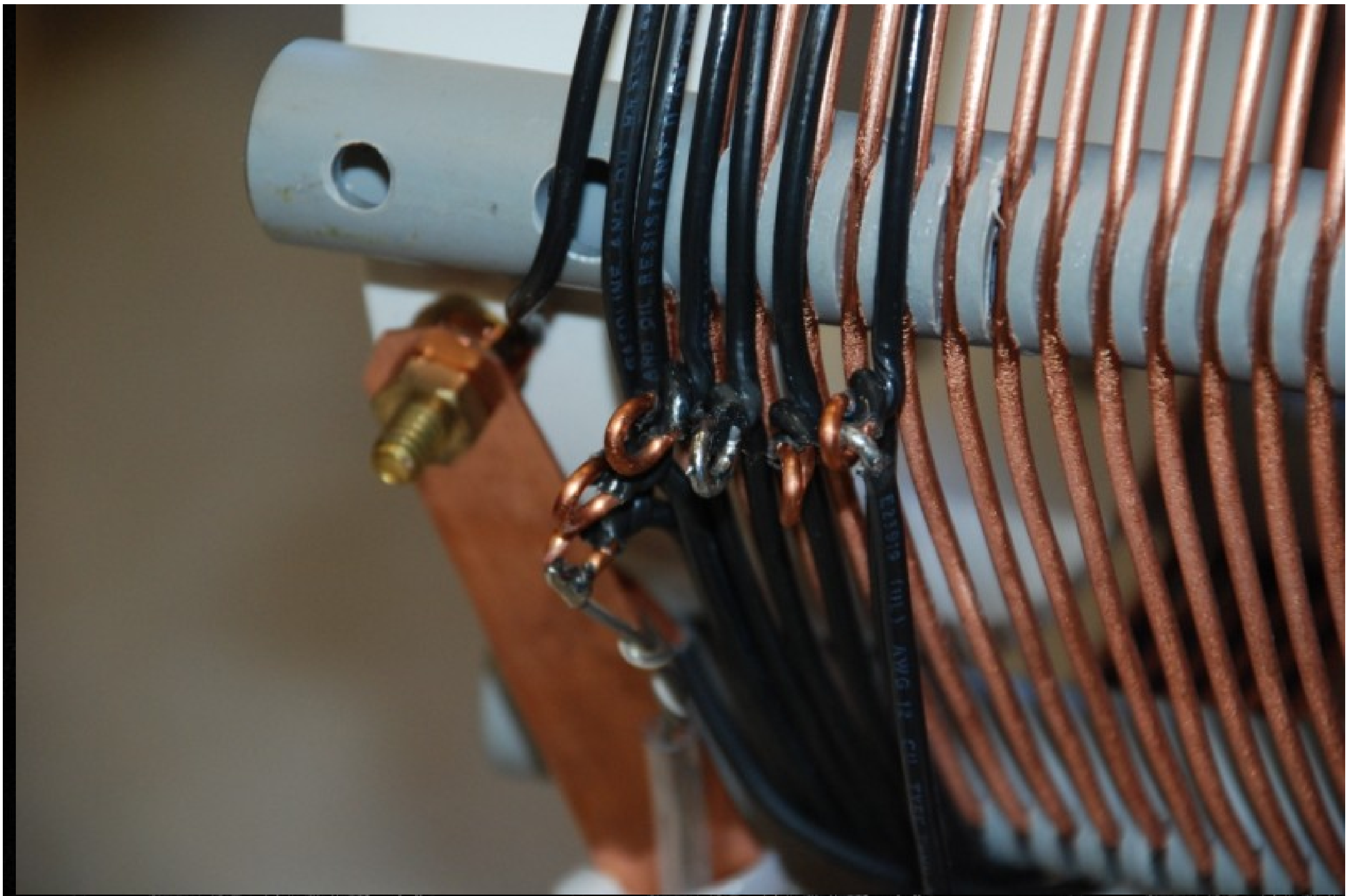
RF Sample Link

I finally settled on a single turn RF sample link to obtain some RF for monitoring the waveform of the amplifier. I simply wound it over the outside of the coil form. There is nothing special about this configuration, I just happened to have some left over #12 THHN insulated copper wire that was coiled into a circle that size. It fit perfectly, and worked well, so I left it there.





This view of the RF sample link shows it connected to the small "Zip Cord" transmission line that goes to the front panel BNC connector for the RF output sample.

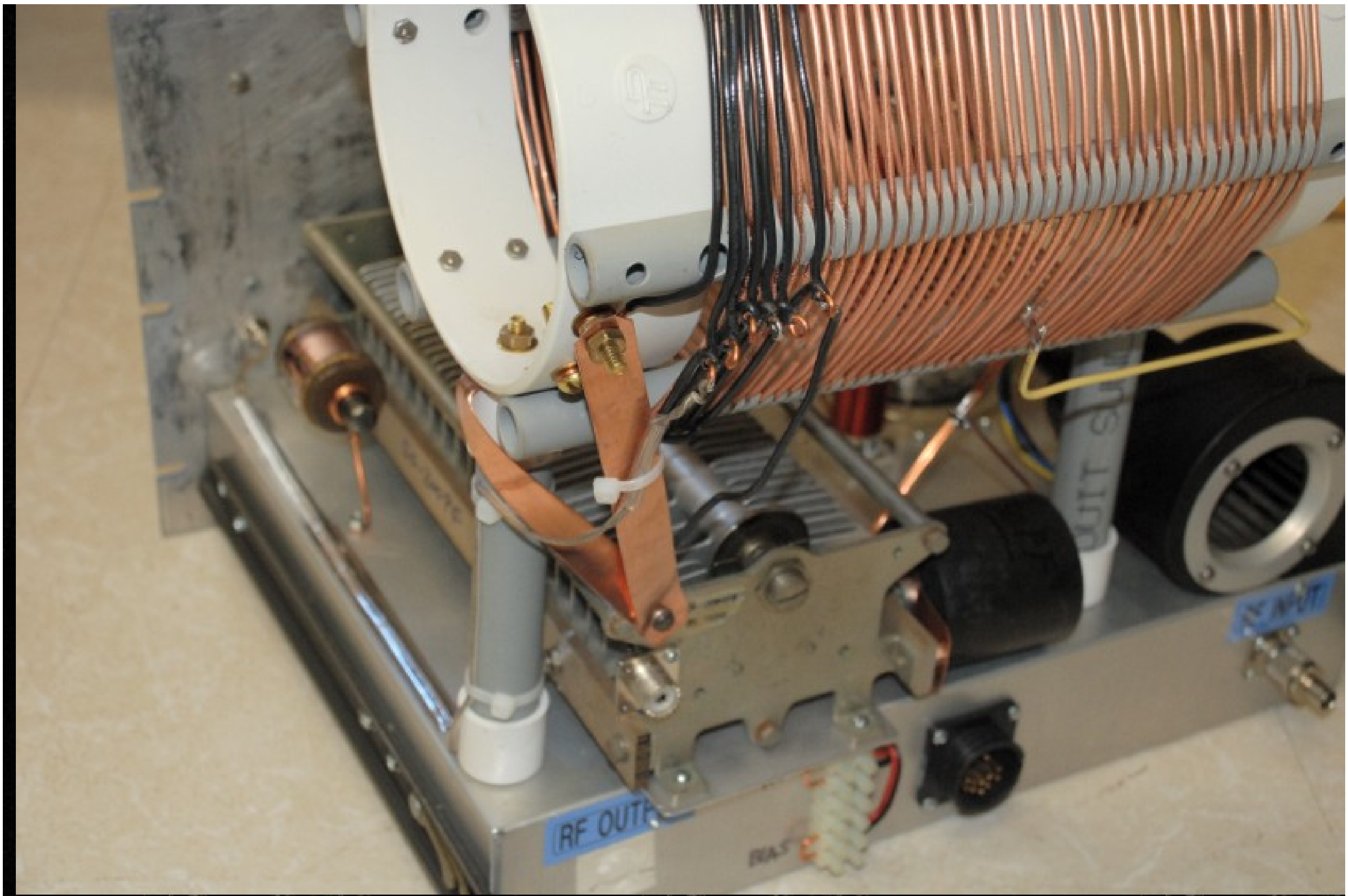


RF Output Link Coil Taps

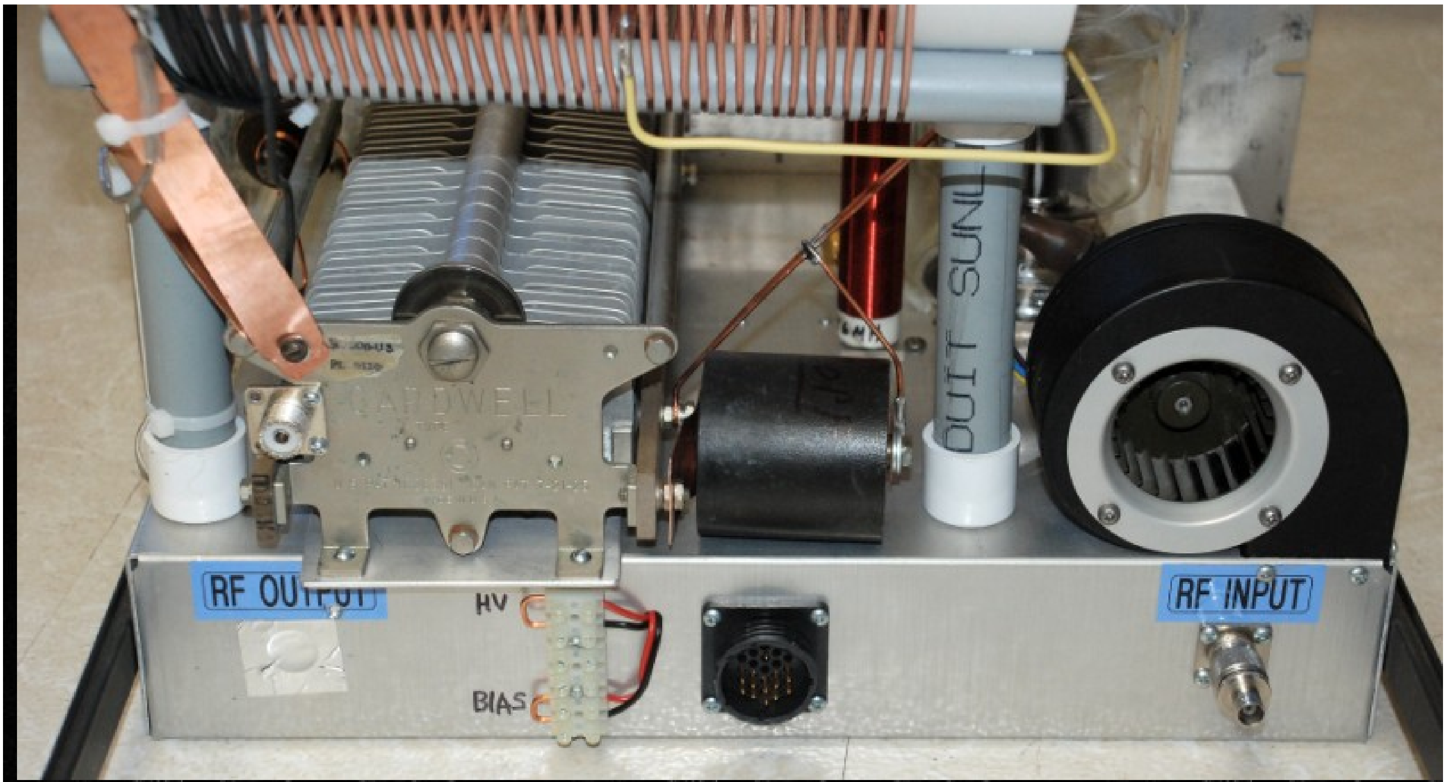
Oh my! How messy! But, it works.

The RF voltage is fairly low on the link taps, and making a simple twist in the wire while I was winding the link coil provides for a fast and easy way to adjust the coupling. You can see that I thought I had the correct coupling tap, and I had soldered the output wire to the fourth tap from the left. However, I determined that the tap position was incorrect. You can see that the output wire is now just hanging inside the connection on the last turn to the right of the link coil.

If you look carefully, you can see that the yellow RF sample link had not yet been added when this photo was taken. Also, note that one side of the "Zip Cord" transmission line from the RF sample connector si connected to the tap on the first turn of the link coil. This proved to be a big "No-No" because the RF voltage on the first turn of the link coil was high enough to overheat and melt the plastic insulation on the "Zip-Cord."



Here you can see the copper grounding straps for the cold end of the link coil and the cold end of the plate tank coil. They are connected directly to the plate tuning capacitor frame, which is in turn grounded directly to the chassis. Because the tuning capacitor was too long to fit on the chassis, an adapter plate was added to the rear of the tuning capacitor to enable the back end of the tuning capacitor to sit slightly to the rear of the chassis.



Rear View of the Amplifier

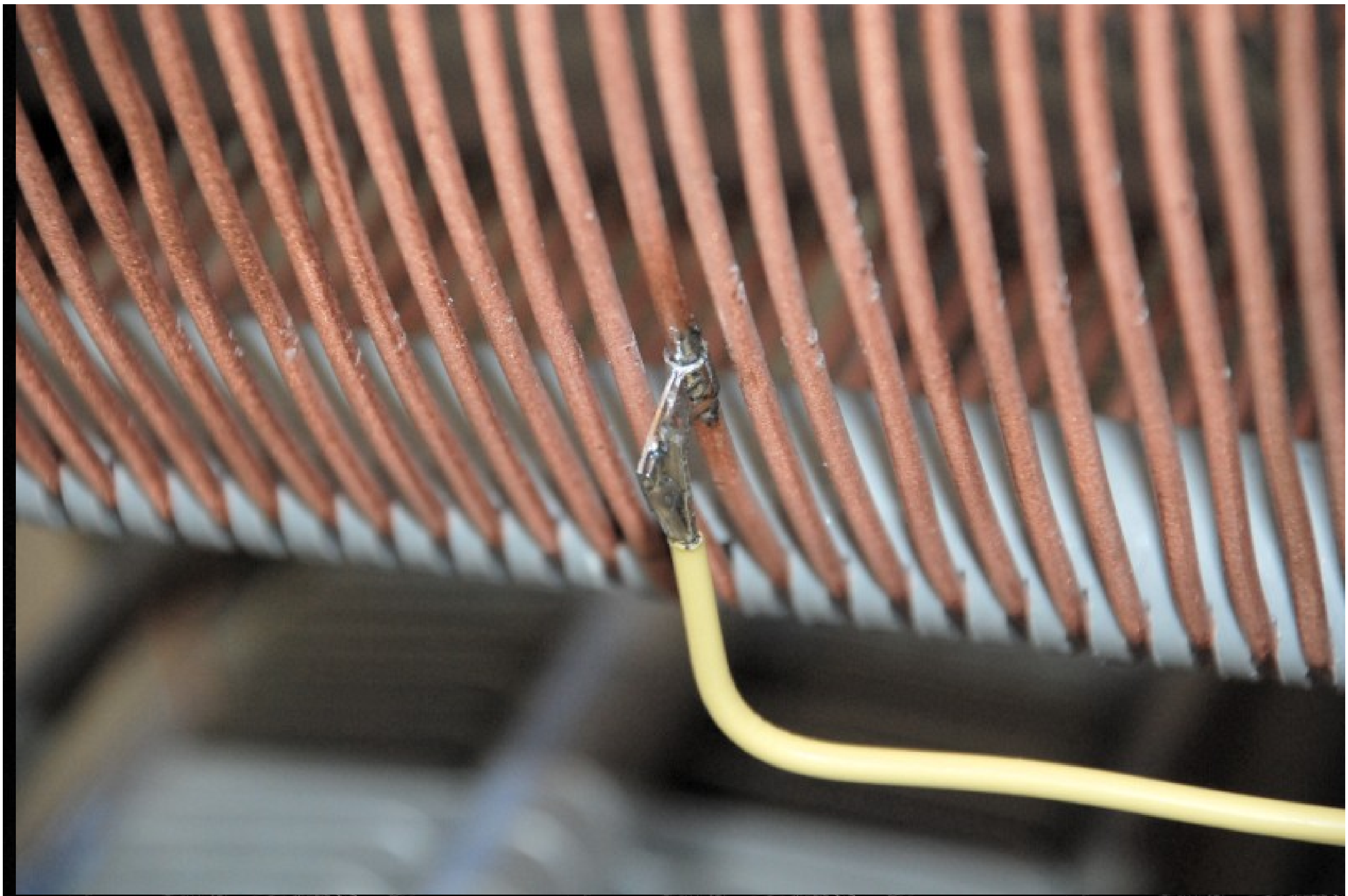
You can see the yellow wire that connects the RF blocking capacitor from the 4-400A anode connection to the "hot" end of the tank coil. All of the turns in the coil from the point where the yellow wire connects to the coil to the right side of the coil are not used. They are simply left open circuited. Because there were no unwanted resonances in the open section of the coil, there were no high voltages built up across the open turns, and they could be safely left open. I also tried shorting out the extras turns, but this increased the tank circuit losses by about 25 watts, so I left the extra coil turns disconnected.

The black cylindrical capacitor to the right of the tank tuning capacitor is the 10 KV 830 pF Mica capacitor that is in shunt with the tuning capacitor. The cooling blower is to the right of the right-hand PVC pipe support for the tank coil.

The RF output connector was originally planned to be fed through the rear of the chassis, but it turned out to be better to place it directly on the tuning capacitor. This avoids high RF current flow from the capacitor frame to the chassis and lessens the potential for RF feedback.

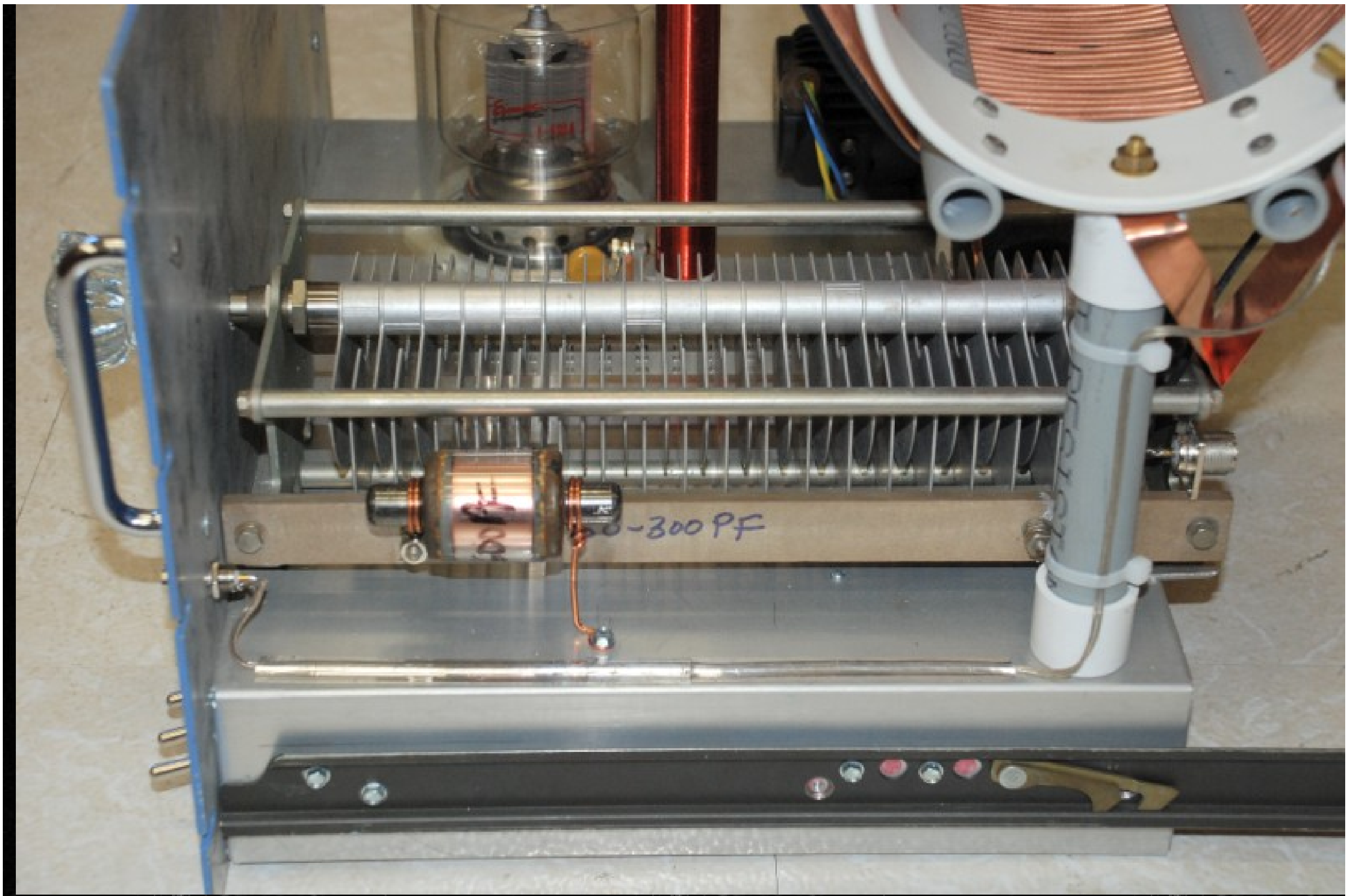
The plastic terminal strip has connections to allow the plate voltage supply to be switched on and off from the operating position, and to change the bias on the 4-400A tube from operating to beyond cut-off for receiving.

The black plastic connector has all the interconnect lines between the power supply chassis and the amplifier, including the +3200 volt plate voltage line.

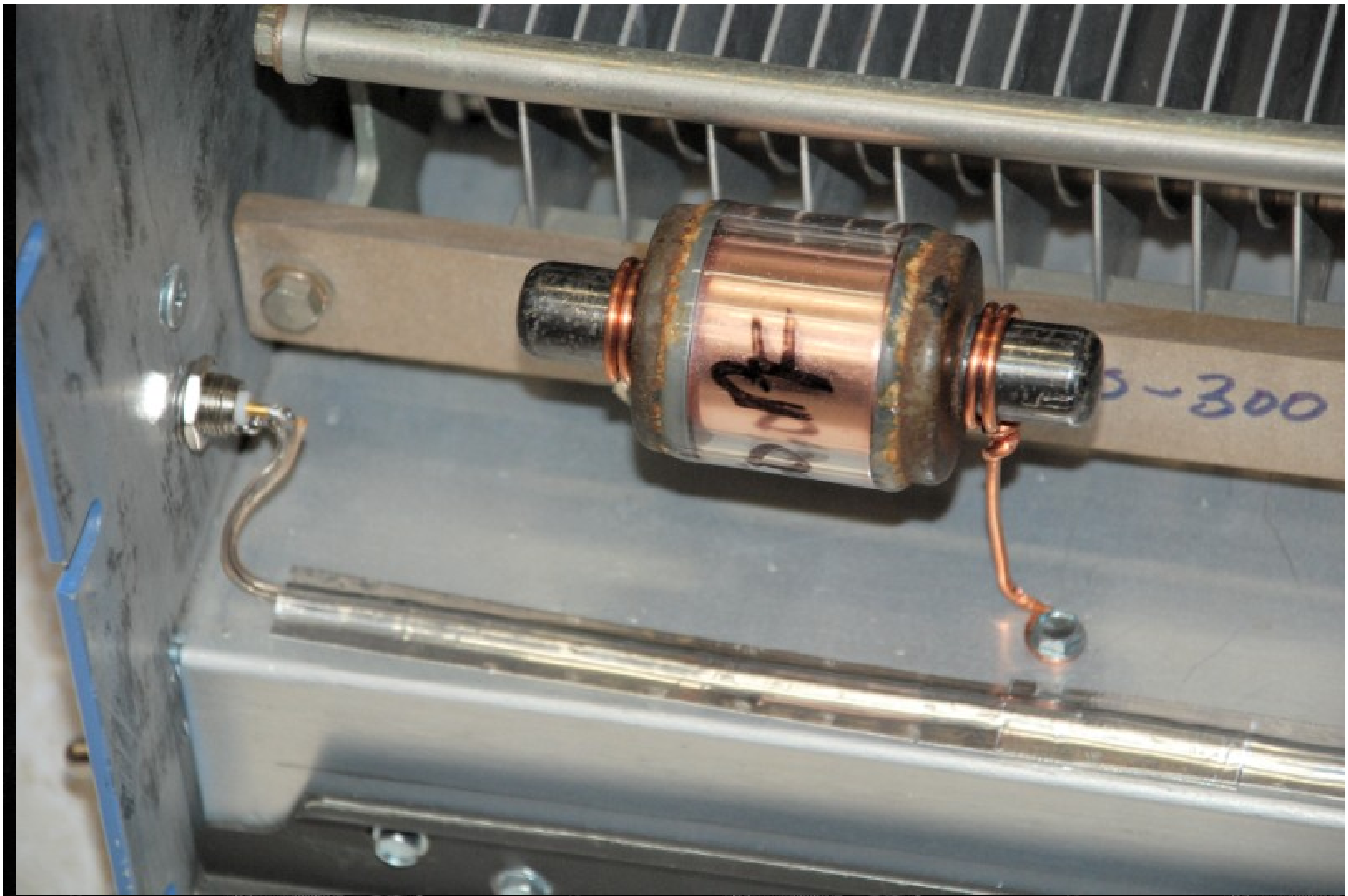


A close-up of the tap on the plate tank coil.

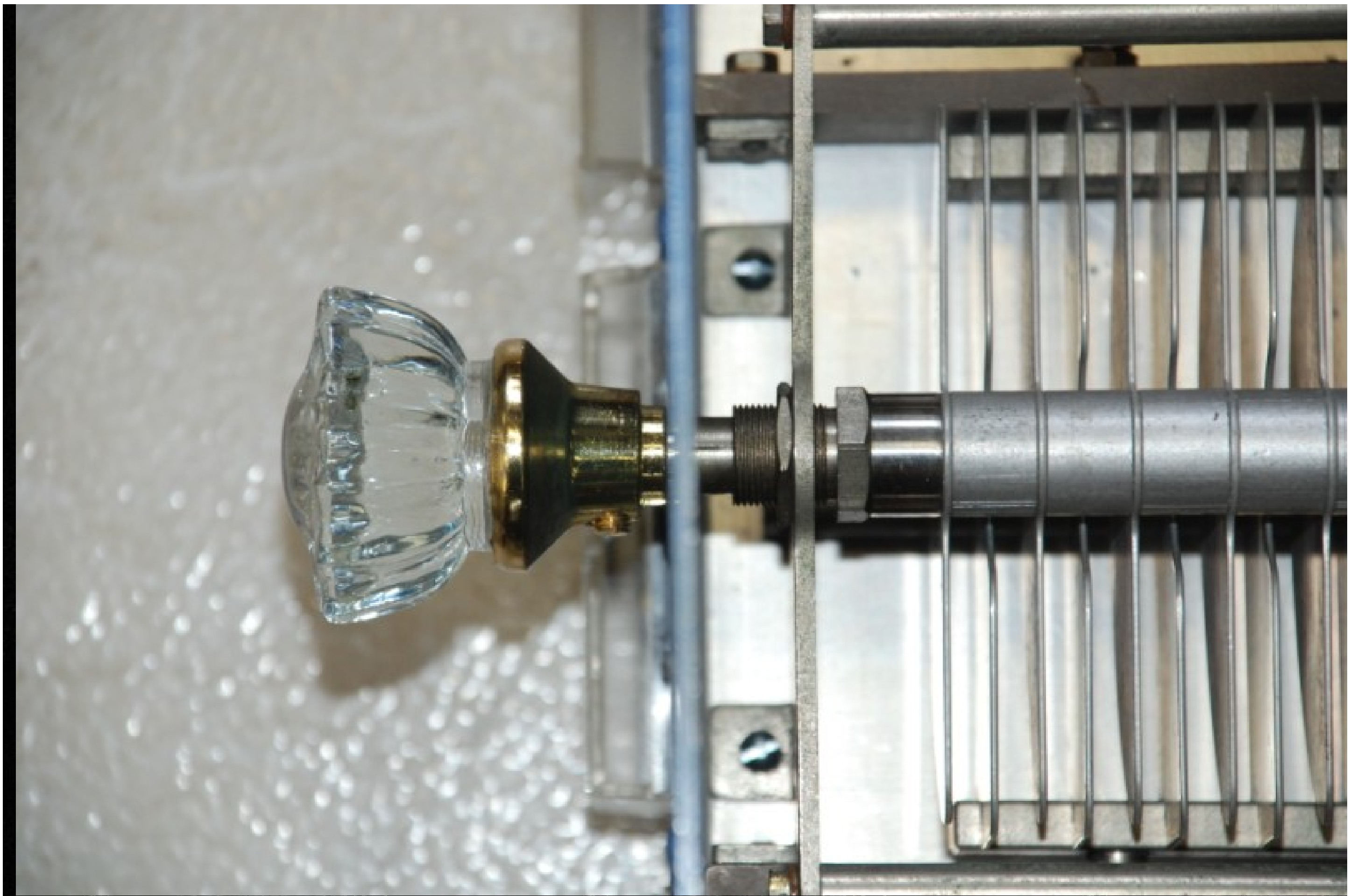
The coil tap is made by taking a small strip of of copper sheet measuring about 1/4" wide by about 1" long and bending it into a "U" shape around a scrap of copper wire of the same gauge as used on the coil. Then the tab is slipped in place over the appropriate turn on the coil. Next, place a pair of slip joint pliers over the tab ends set the end of the pliers flush against the coil turn. Squeeze the tab ends flat against each other. This should form the tab into shape around the wire. Solder the tab ends together, and the tab loop onto the coil turn, then solder the tap wire onto the tab.



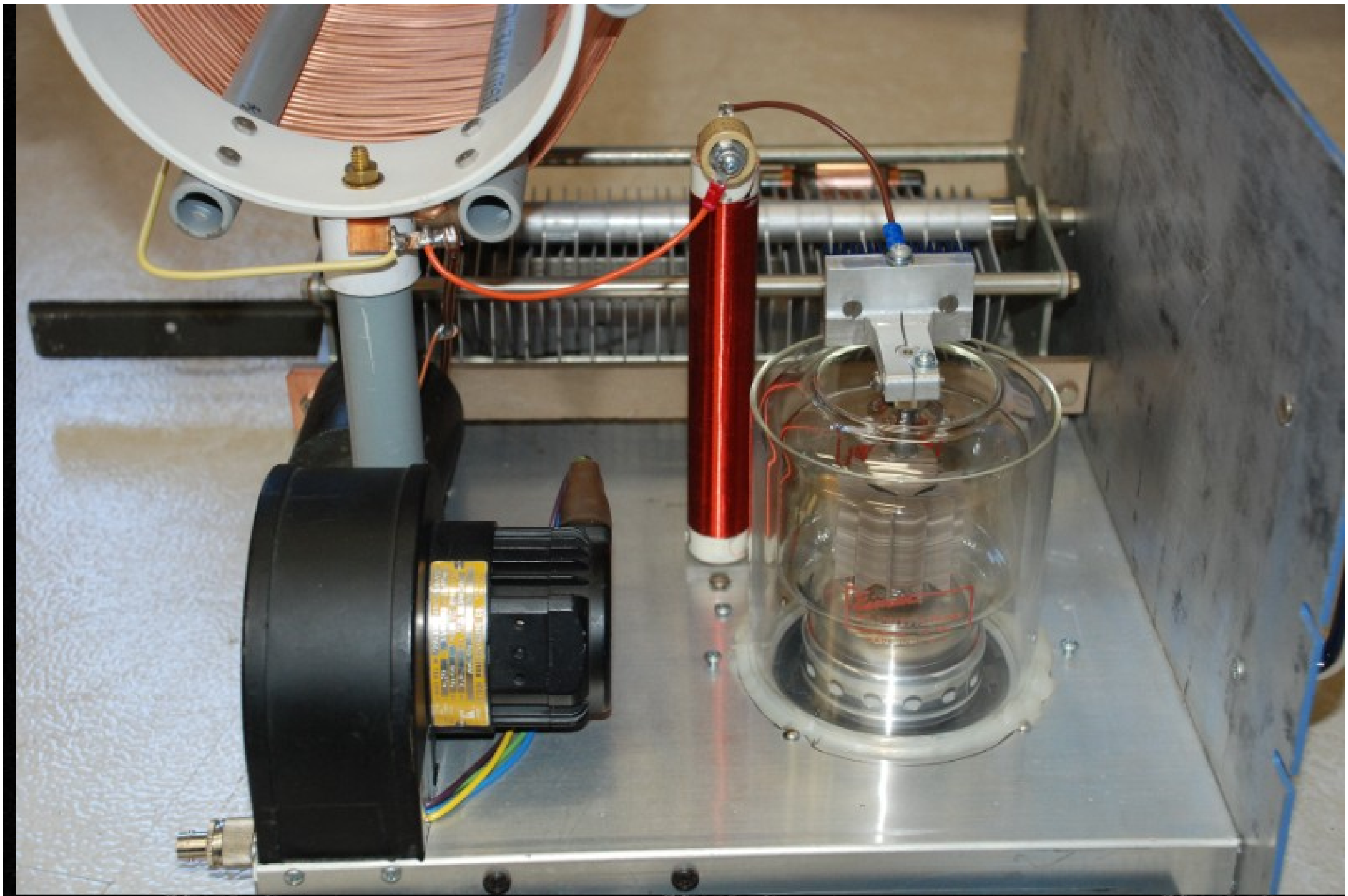
This is the small 50 pF fixed vacuum capacitor that is placed across the main tuning capacitor. If the amplifier is operated at plate voltages of 3200-3500 volts, this capacitor may need to be changed to 100 pF to get the tank circuit to hit resonance.



This is my quick mounting method for the vacuum capacitor. The RF current through the capacitor is low, so the twisted wire connections work OK. Also note the use of aluminum tape to hold down the "Zip Cord" transmission line for the RF sample tap.



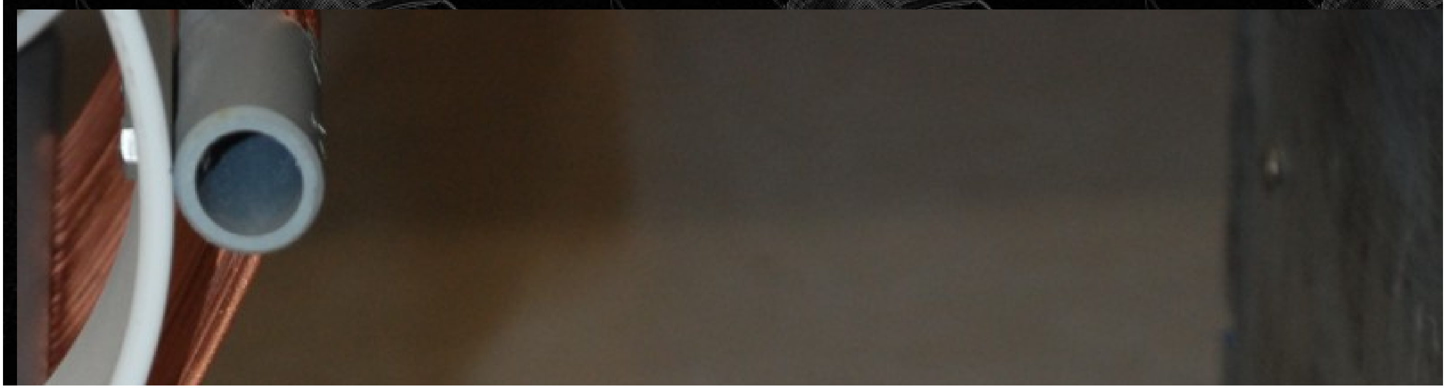
Not having a nice shiny knob for the main tuning capacitor, I remembered that I had several glass doorknobs in the Junk Box. I quickly drilled out the shaft hole to fit the shaft of the tuning capacitor and installed it on the shaft with a setscrew. It works fine, and since it does not have to be adjusted often, no pointer is necessary. And it does attract attention!

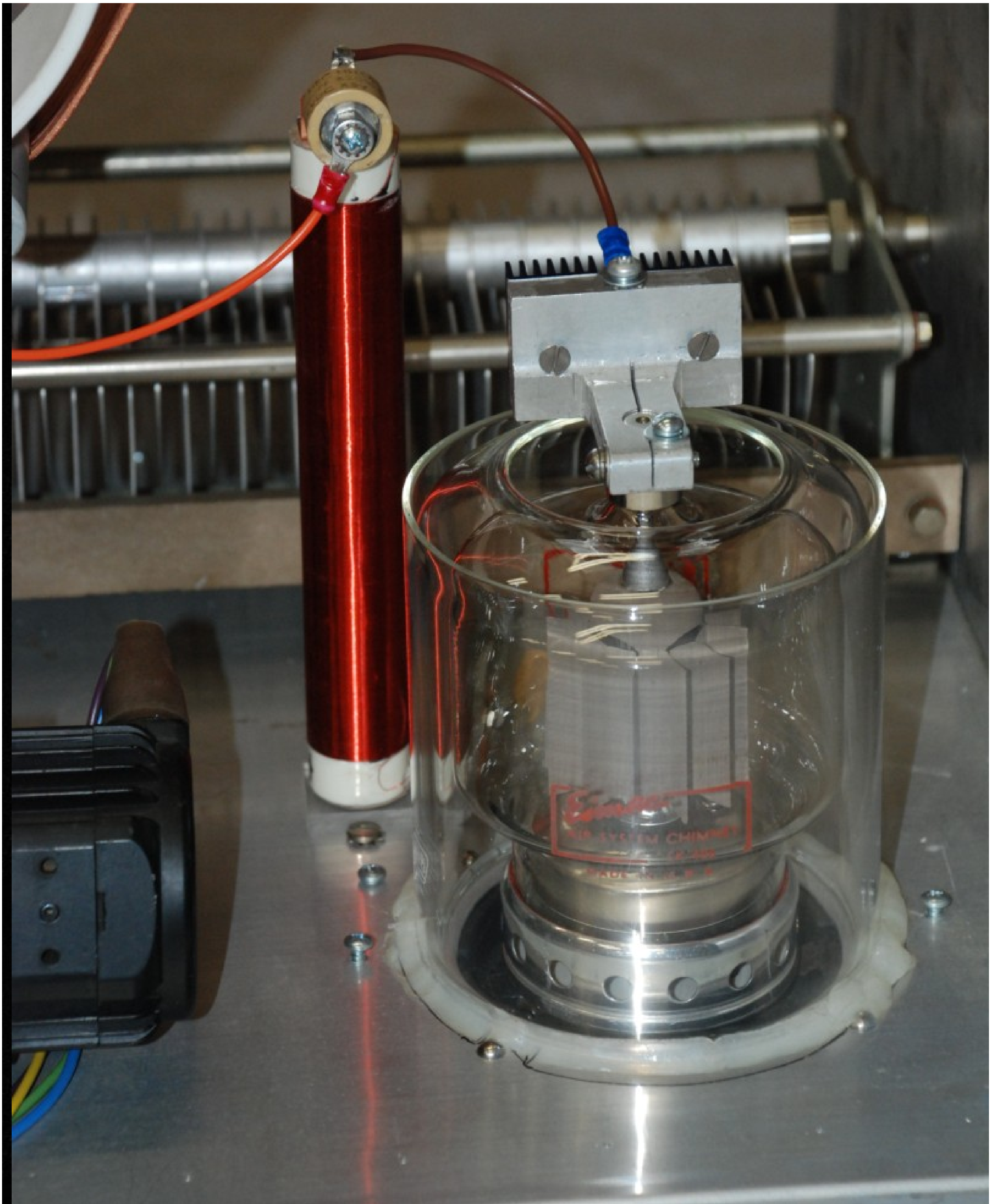


The 4-400A tube installed in the amplifier.

Note the double glass of the cooling chimney. This was accidental. Originally, I had planned to use a 4-250 in the amplifier and not having a standard chimney, I pressed a Coleman lantern globe into service. To save the time and trouble of designing metal clips to hold the glass, I used a bead of RTV adhesive to attach the glass to the chassis. Because the straight sided chimney did not force the cooling air against the plate cap seal, I constructed a rather massive heat sinking plate cap connector (seen here from the reverse side) that has cooling fins that are exposed to the cooling air that flows up and past the side of the tube. This was to keep the anode connection of the 4-250 cool. When I obtained the 4-400A, I also obtained the Eimac chimney. It turned out to be a loose drop-in fit inside the Coleman globe. The turned-in top edge of the Eimac chimney provides the needed air against the anode connection of the tube, but I still used the heat sink plate cap since I had it already. It also adds a bit more cooling for the anode connection.

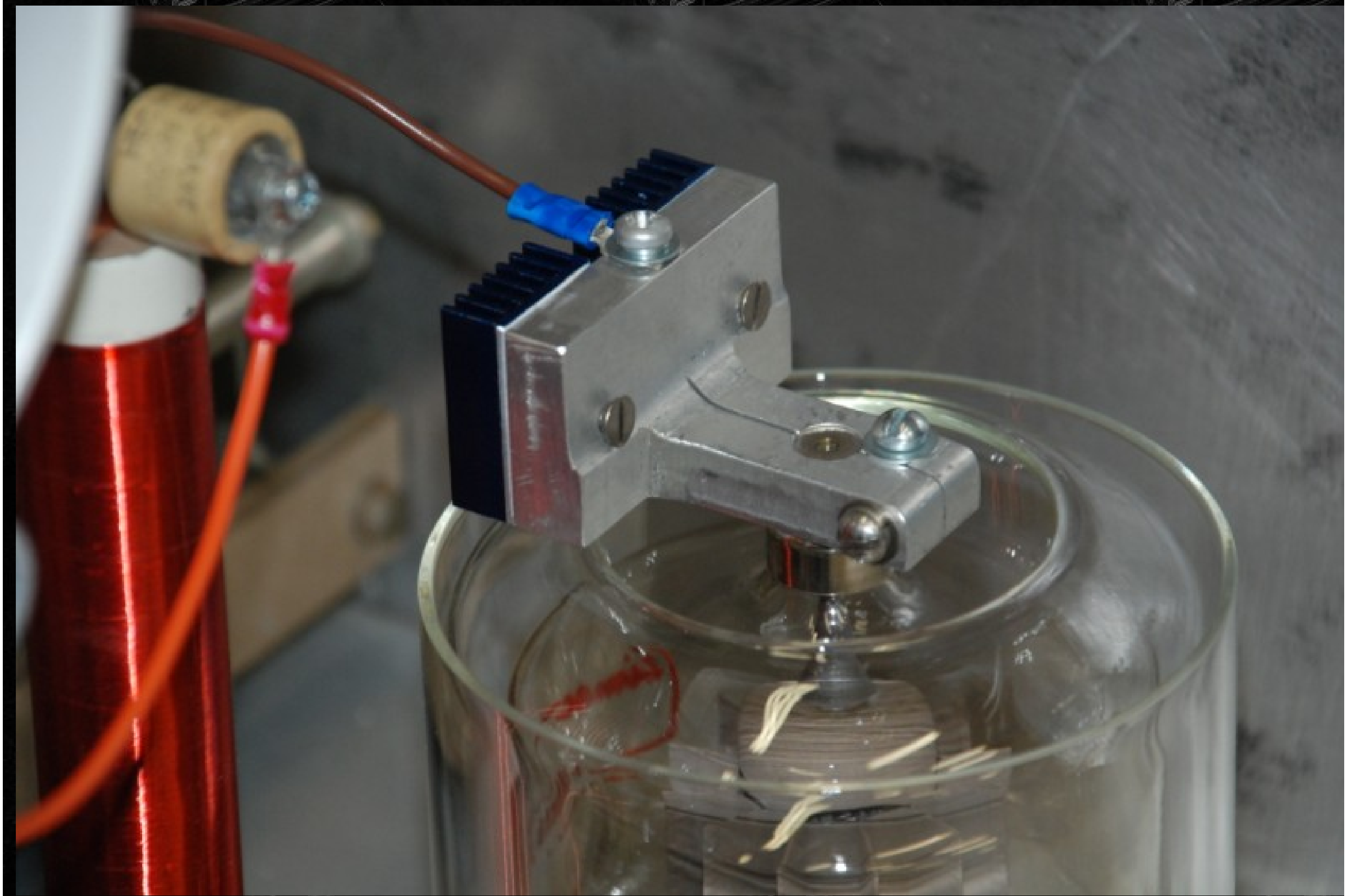
The plate choke is wound on a ceramic stand-off insulator (See PDF for details) and stays cool in operation. There is no parasitic suppressor in the amplifier. As constructed, the amplifier appears stable under all test conditions, with and without load.



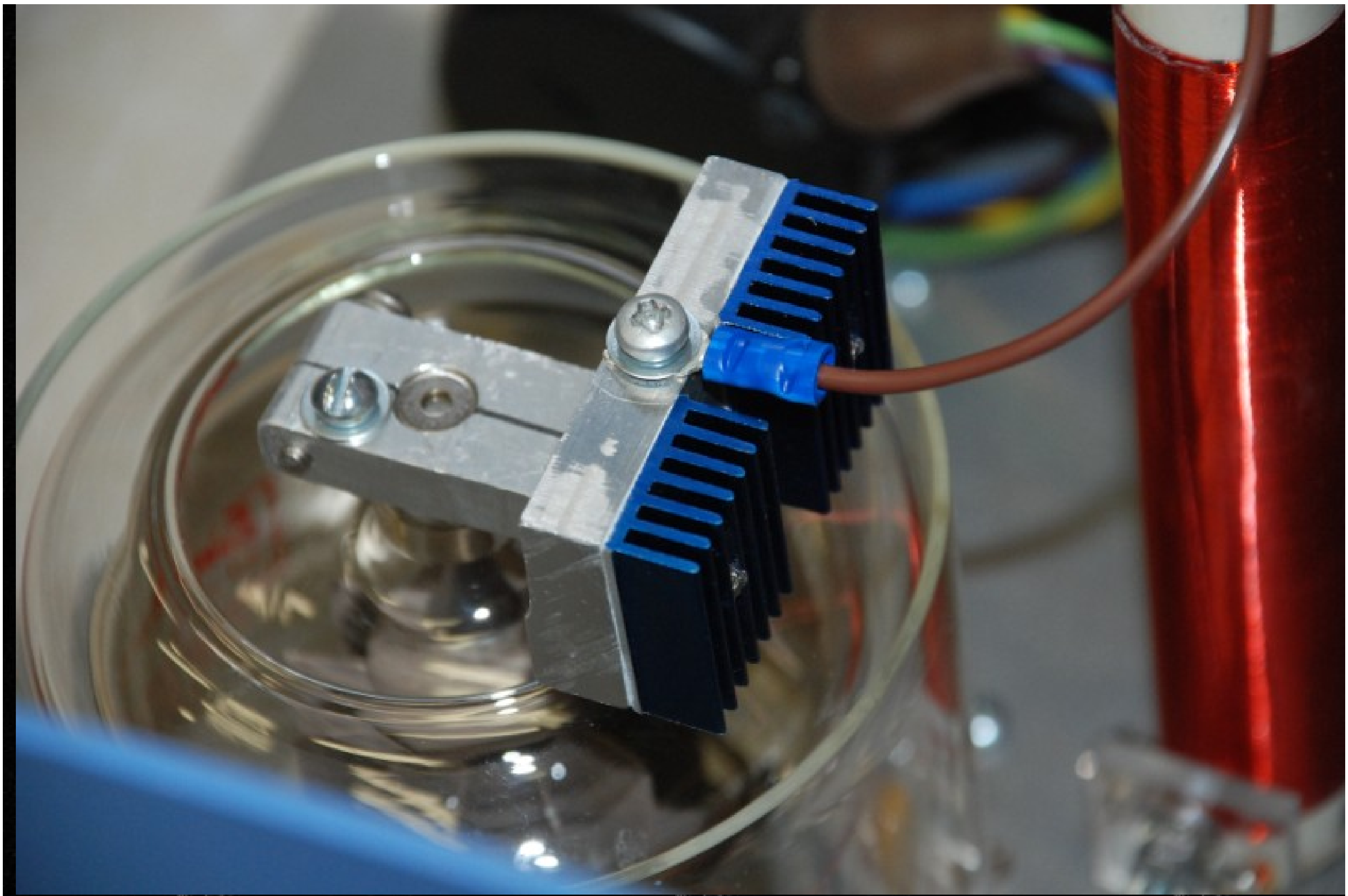


Close up of the tube and RF choke

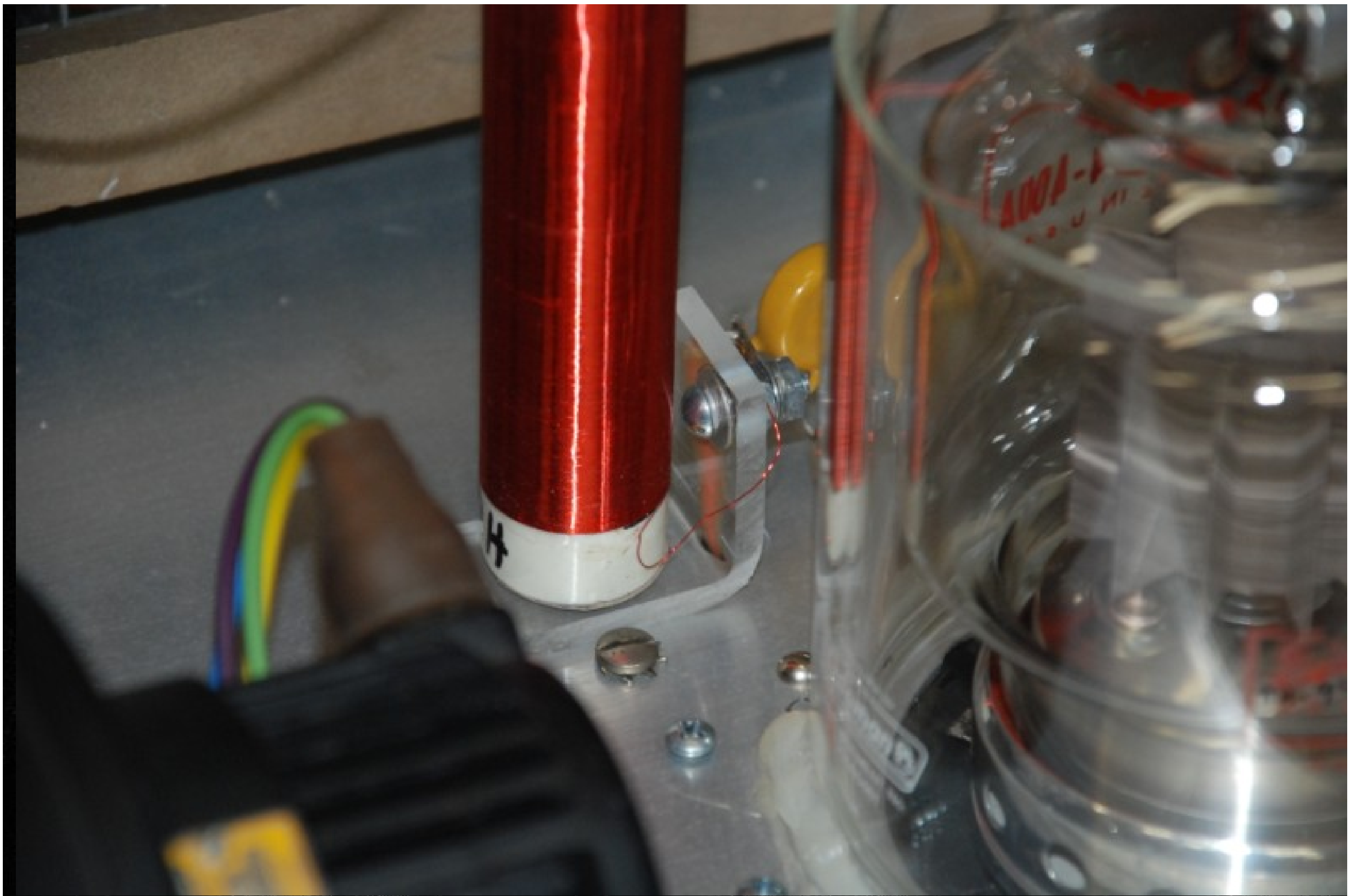
You can see the RTV adhesive bead under the Coleman glass. The RF choke is held against the chassis by a screw that passes up through the chassis. Cushioning is provided between the chassis and the ceramic by a cardboard washer. When I wound the RF choke, I held the end of the wire in place with some electrical tape. After finishing the winding, I applied a drop of Super Glue to the end turns to prevent the wire from unwinding.



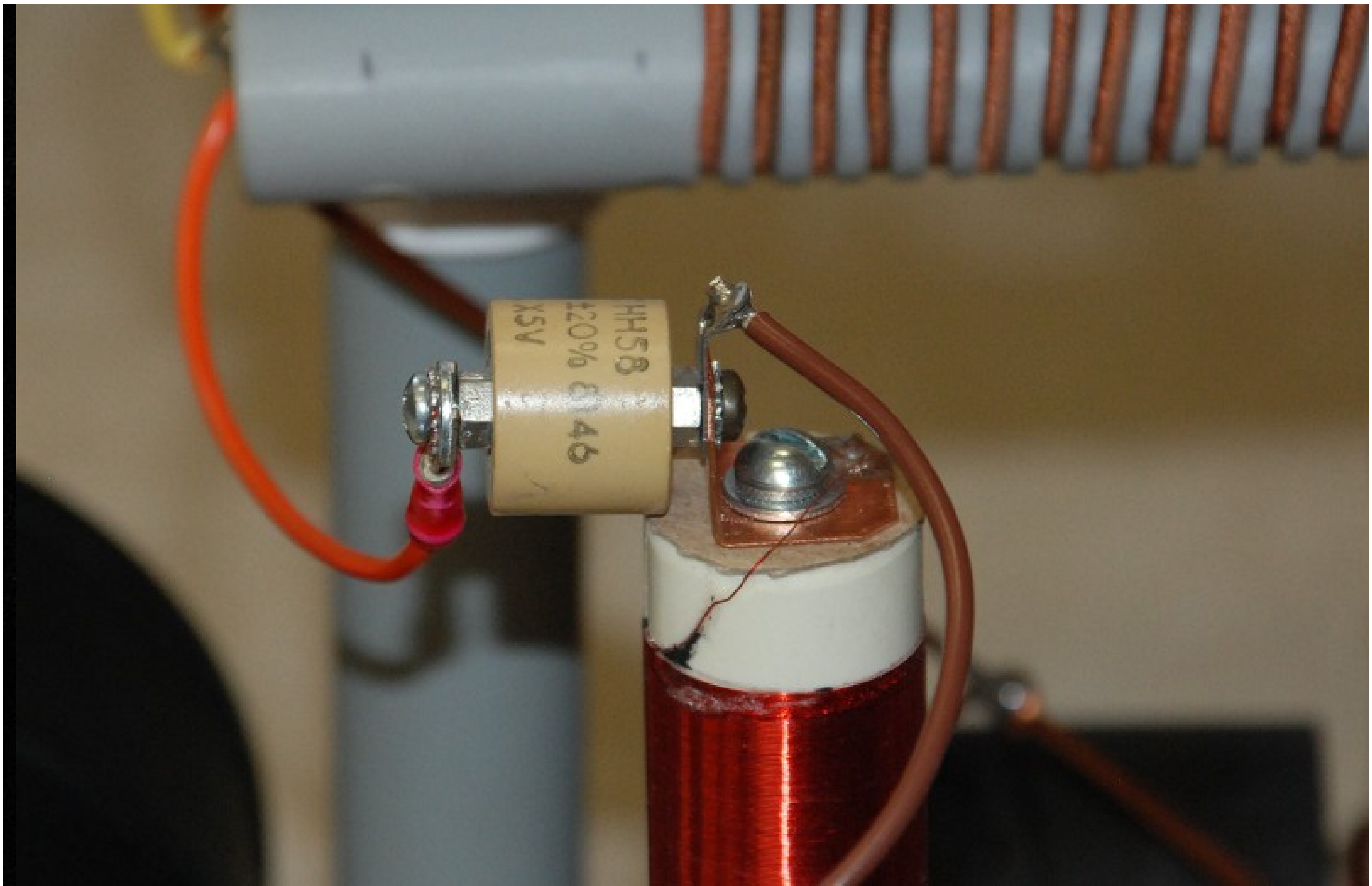
The heat sink anode connector was constructed from a length of 1/2" thick 2" x 2" aluminum angle stock. Two salvaged heat sinks from an old graphics computer system were attached to the side of the assembly. They were designed to be exposed to the air flow as it passed over the tube.



Looking at the connector from the other side shown the two heat sinks.



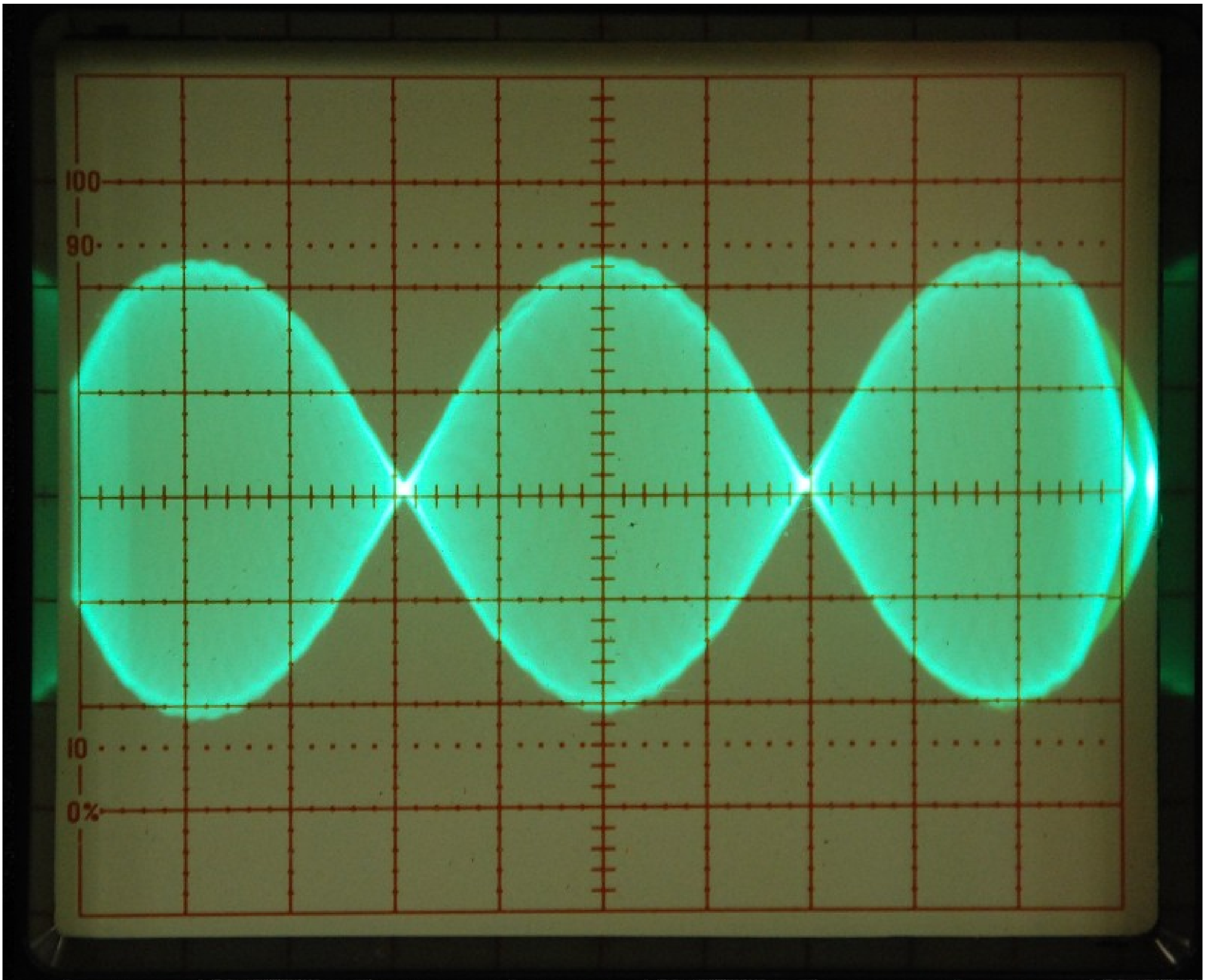
This is the bottom plastic insulating bracket that holds the choke lead that connects to the +3200 volt supply.



I made a small copper "L" bracket to hold the plate blocking capacitor on to the top of the plate choke. The top of the choke winding is soldered to the copper bracket. I placed another cardboard washer between the copper bracket and the ceramic insulator to prevent cracking the ceramic. The black smudge across the lead-out wire is not from arcing, it is residue from the black electrical tape that got stuck to the Super Glue.

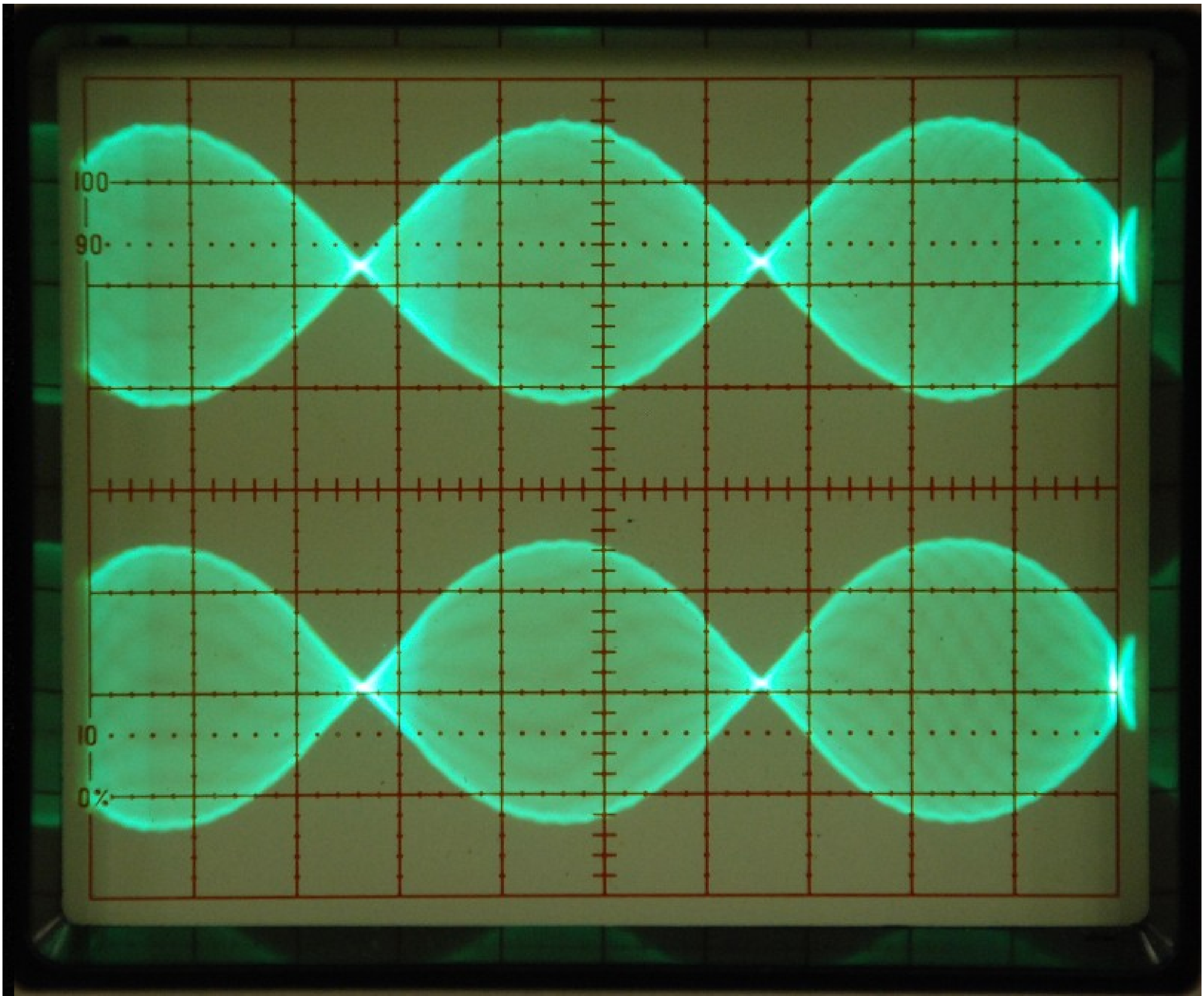
A view of the front panel of the completed amplifier. The glass knob adjusts the PA Tank circuit tuning capacitor. The BNC connector under the chrome handle is the Output RF Sample tap connector. The only thing missing is a window to allow visitors to the shack to see the 4-400A in operation. The original design of the amplifier did not require a window, and so unfortunately I forgot about it until I had completed construction of the RF deck. At that point, I was somewhat reluctant to take a chance on damaging the meters or anything else due to the heavy vibration caused by cutting a large opening through the thick front panel, so no window, at least for now.

The small black knob is the adjustment potentiometer for the grid bias voltage. The screwdriver adjustment is for the tuning capacitor for the RF Driver output transformer T1 secondary. It is adjusted once and left alone, so there is no need for a knob.



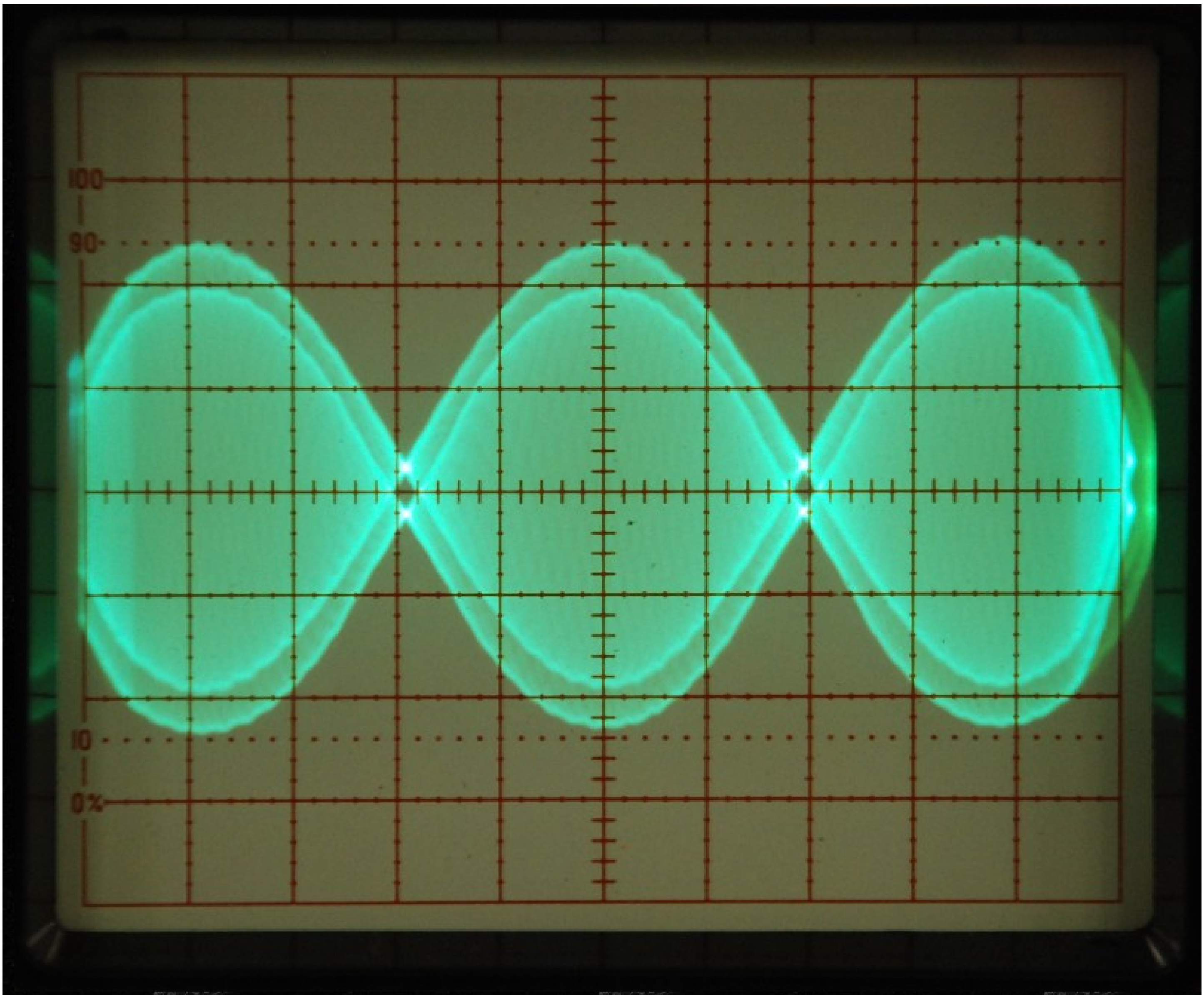
RF Input and Output Waveforms Superimposed

Believe it or not, this is an actual photo of both the RF drive signal to the amplifier and a sample of the RF output from the amplifier taken at the dummy load. It is virtually impossible to discern the two waveforms from each other, indicating that the amplifier is quite linear over the operating curve. This photo and the following two waveform photos were taken at the 500 watt peak power level.



RF Input and Output Waveforms Separated

The top waveform is the RF drive, and the bottom waveform is the RF output.



RF Input and Output Waveforms Offset

The top waveform is the RF drive, and the bottom waveform is the RF output. The slight AC-looking ripple riding on the top of the waveforms is the result of artifacts in the RF drive signal from the Starpoint channel modem. It is caused by a leaking transistor in one of the balanced bridge circuits in the modulator.

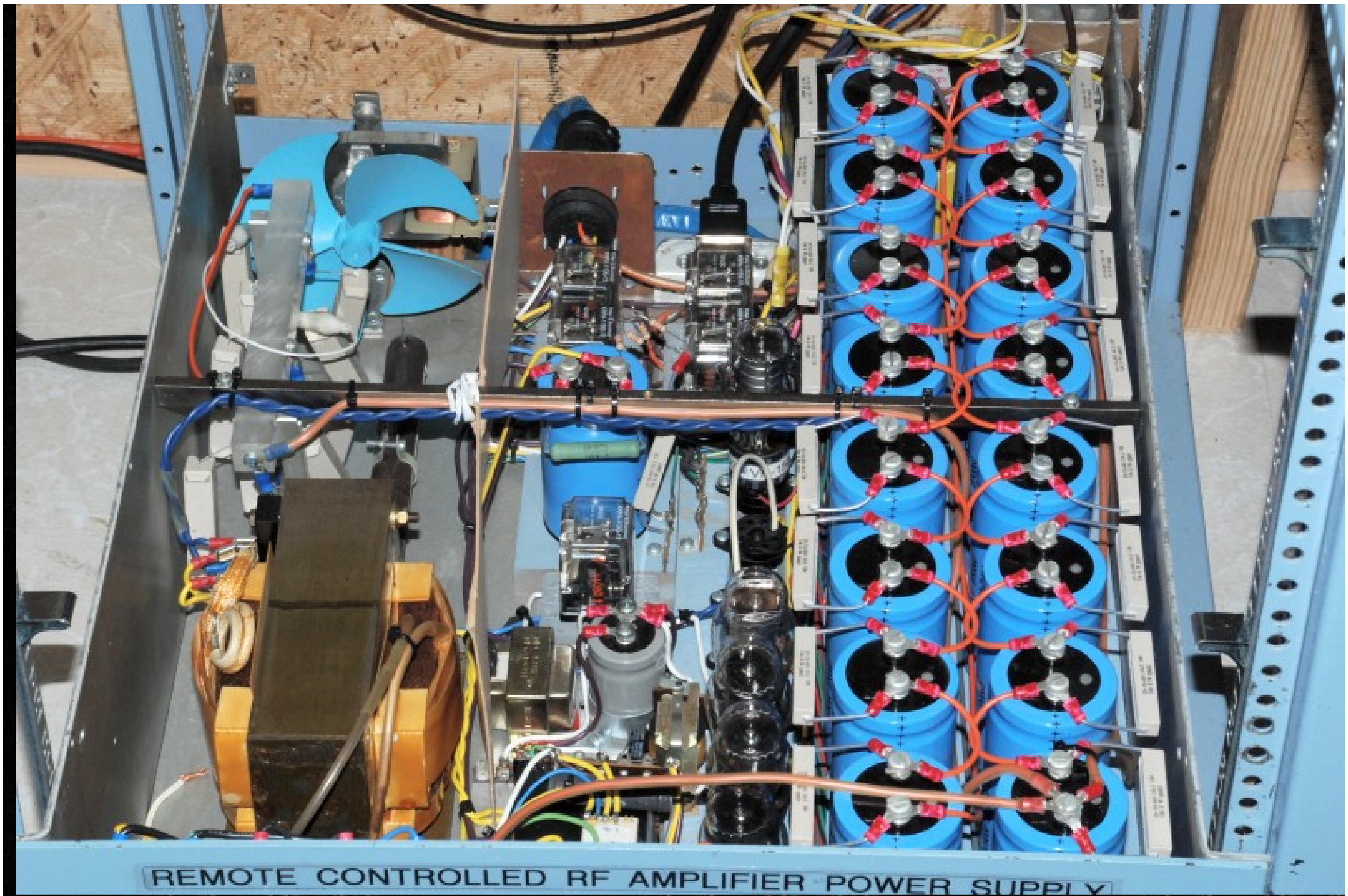
The amplifier in the rack on the right side of the photo is the 600 meter amplifier discussed in this article. The amplifier on top of the cabinet in the left of the photo is a partially assembled 1-KW grounded-grid amplifier for 160 - 10 meters.


GRID CURRENT
PLATE KILOVOLTS
PLATE CURRENT
REMOTE CONTROLLED RF AMPLIFIER POWER SUPPLY
WARNING! LETHAL VOLTAGES INSIDE!
IN-TOWN MOVES
16X12X12

Front view of the amplifier rack

The RF deck sits in the top of the rack so the hot air from the amplifier can exit the vents on the top of the cabinet. (All the panels have been removed for this photo and during testing.) The power supply is in the bottom of the rack. The center shelf holds the Starpoint channel modem and a CD player used for providing the necessary audio signals for testing. The oscilloscope is used for monitoring the output waveform from the amplifier. Sharp eyes will note the missing bias pot knob and the RF driver tuning capacitor. Also missing is the yellow single turn RF sample loop around the right hand side of the plate tank coil. This photo was taken before those items were installed.

My Bird 43 in-line wattmeter is seen hanging from the 1200 Watt Bird dummy load that is mounted on the wall behind the amplifier racks. It's out of the way, and gets plenty of clean cooling air. I just connect it to whatever unit I am testing and then roll up the cable when I am done testing.



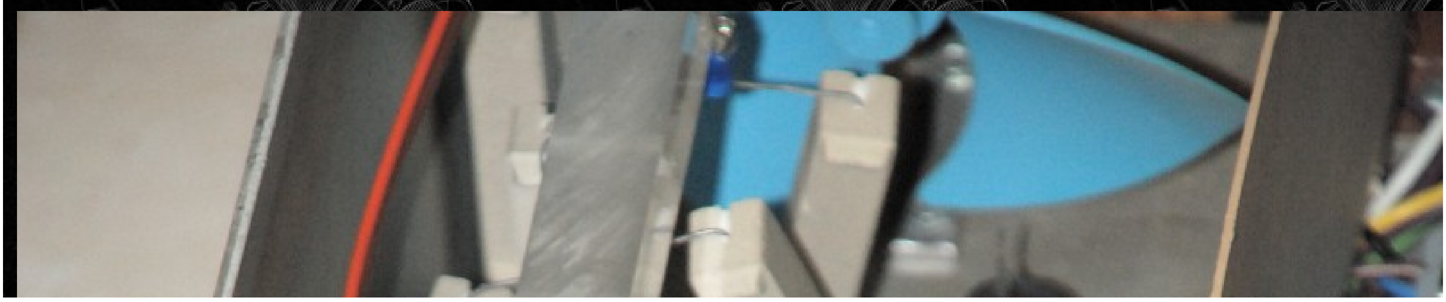
A top view of the main power supply with the protective top cover removed.

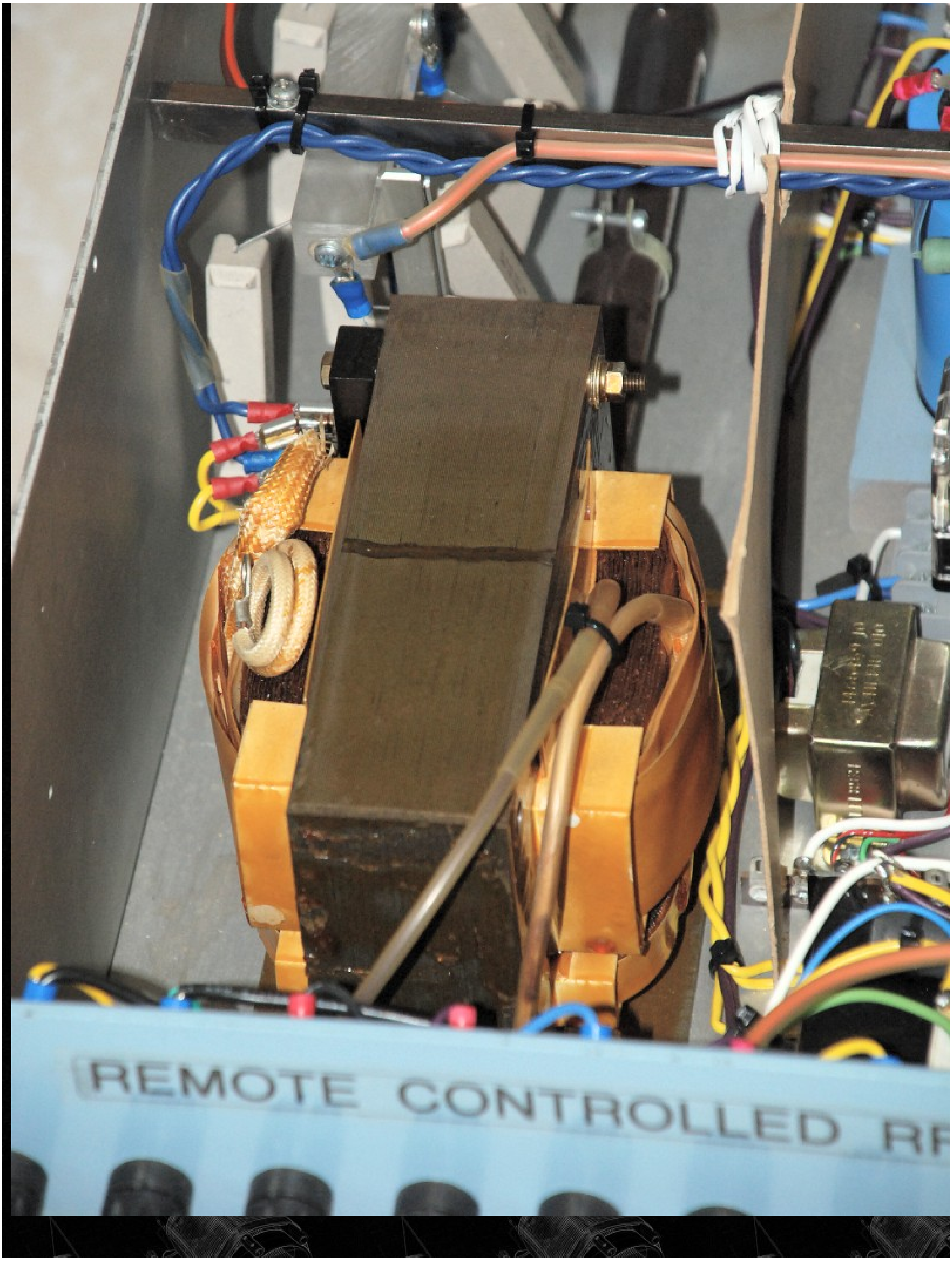
From top to bottom at the left - the cooling fan, the screen dropping resistors, the microwave oven high voltage transformer.

From top to bottom in the center - the AC power cord and RFI line filter, the remote control cable and connector, some of the control relays, blue bias voltage filter capacitor, single VR-150 bias regulator tube, another control relay, the small silver colored control voltage transformer and gray filter capacitor, open frame overcurrent relay, 4 VR-150 screen voltage regulator tubes, partially obscured grid bias power transformer.

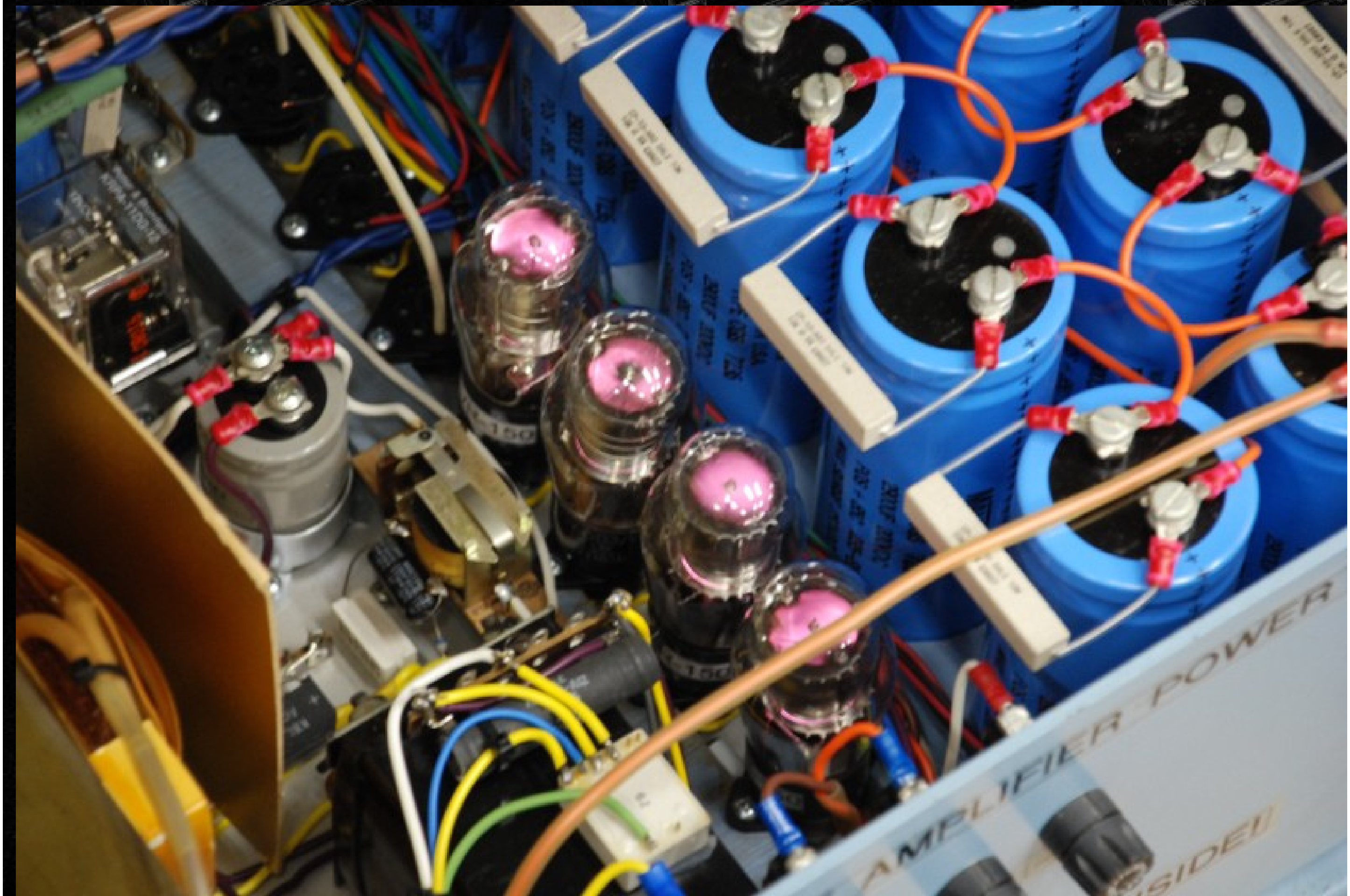
Right side - 16 high voltage filter capacitors with their associated voltage equalizing resistors.

Construction note - I did not have the space to mount all the metal clamps to hold down the filter capacitors, so I took a one inch thick board and used a hole saw to cut a series of 16 holes in the board that just fit the capacitors. I placed that board on top of a second board of the same size and screwed the boards together. Then I inserted each capacitor into one of the holes. I used a small spot of adhesive to hold each capacitor tightly in place. All the capacitors were matched for capacitance and leakage current at full rated voltage before installation and burned in for 48 hours at full voltage, and then retested. Only those capacitors that matched within 2% were used in the power supply.

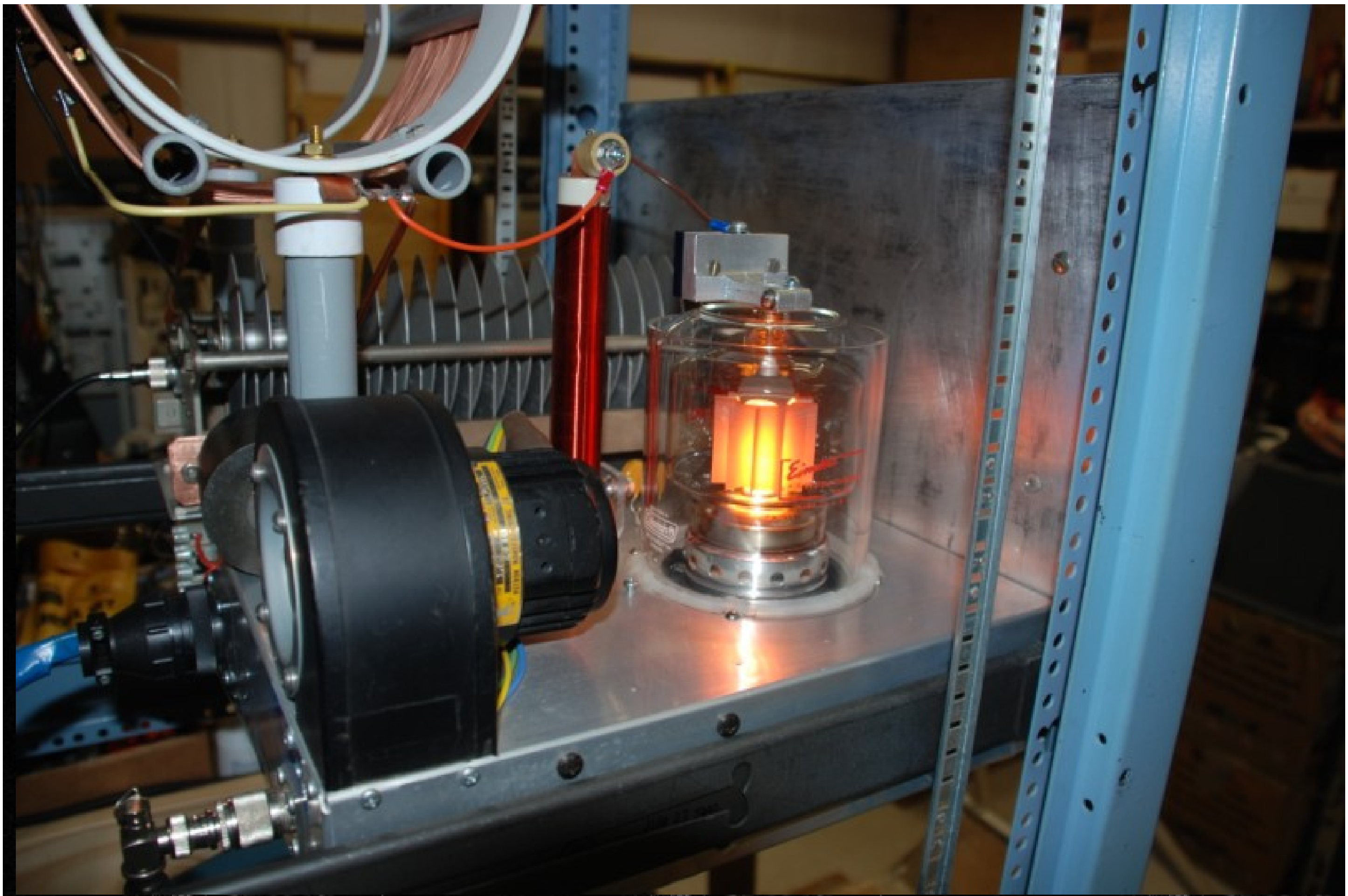



REMOTE CONTROLLED RF

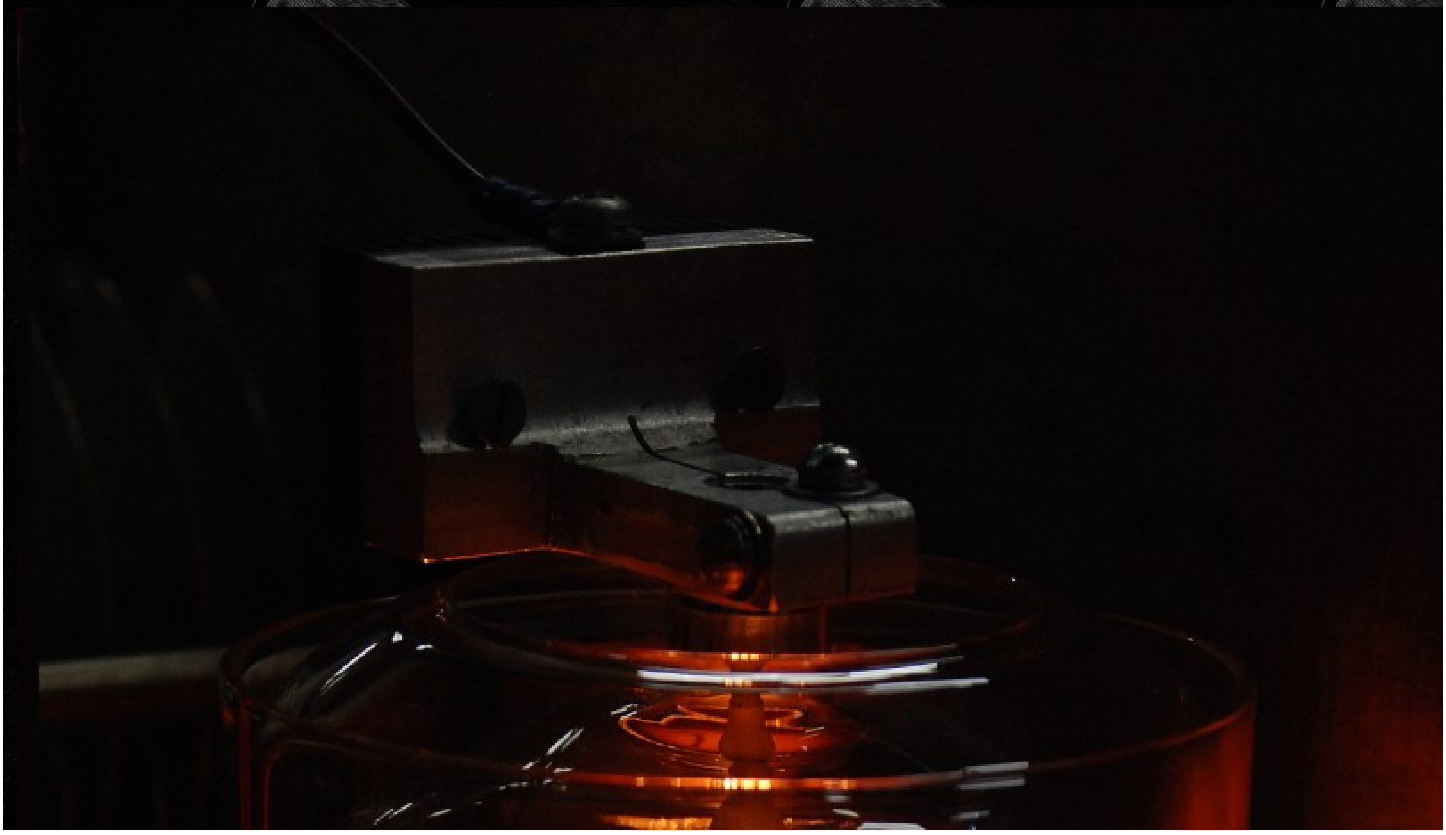
This is the modified microwave oven power transformer. The high voltage bridge rectifier is between the front panel and the transformer and is not visible in this photo. The screen dropping resistors are seen above the transformer. They are arranged in a zigzag vertical arrangement and supported by two plastic bars, one above and one below the resistors. Behind the resistors and partially out of the photo is the cooling fan with the blue plastic blades that provides air to the power supply.

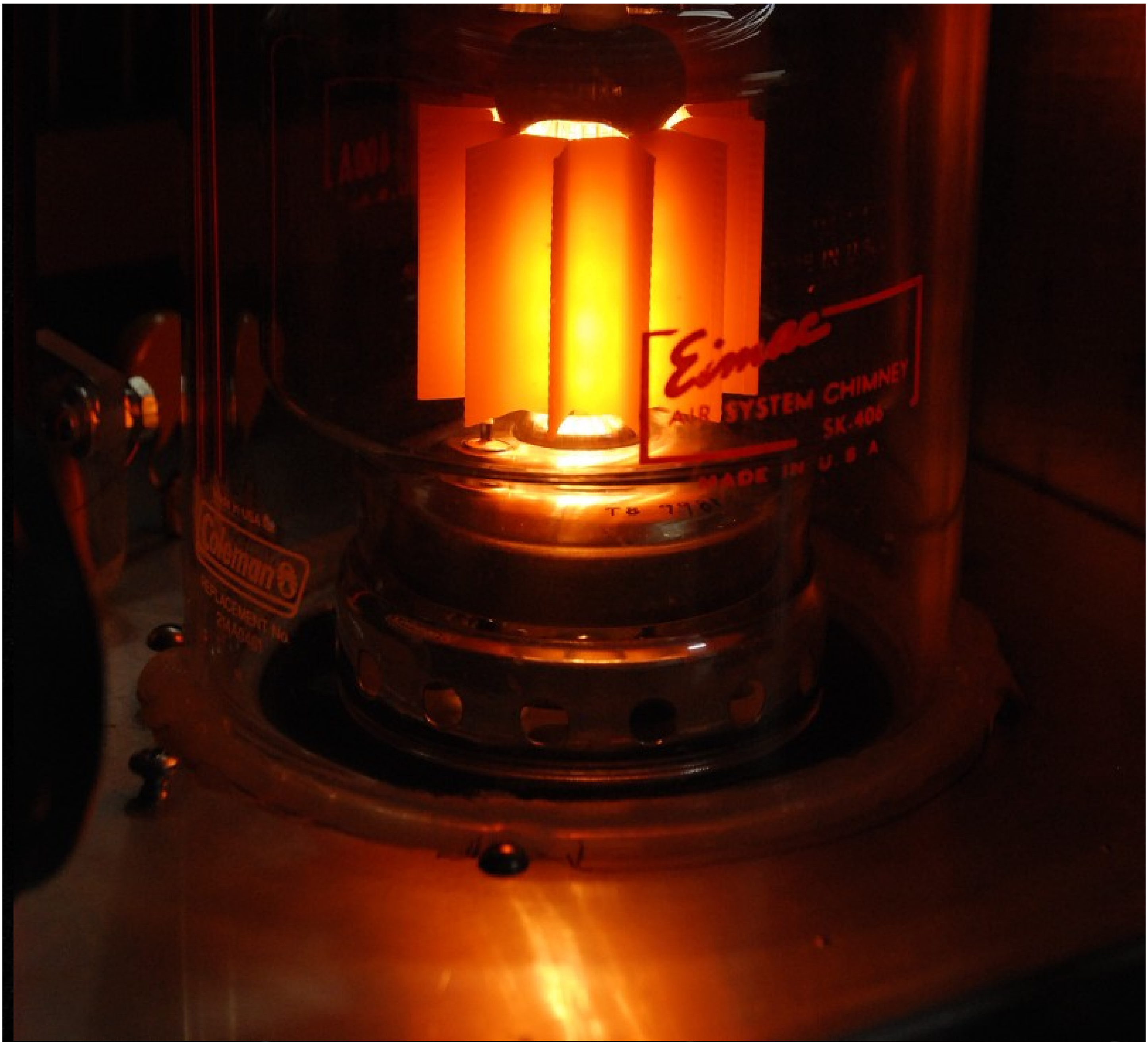


The 4 VR-150 Screen Voltage Regulator tubes are shown in operation. The metal cover plate that is normally in place over the top of the power supply was removed for this photo. It is left in place during operation both for safety for the operator and visitors to the shack and to ensure that the cooling air from the fan circulates through the power supply in the proper manner.



Here the 4-400A is seen running PSK-31 at 400 watts output. It is quite happy at this power level.



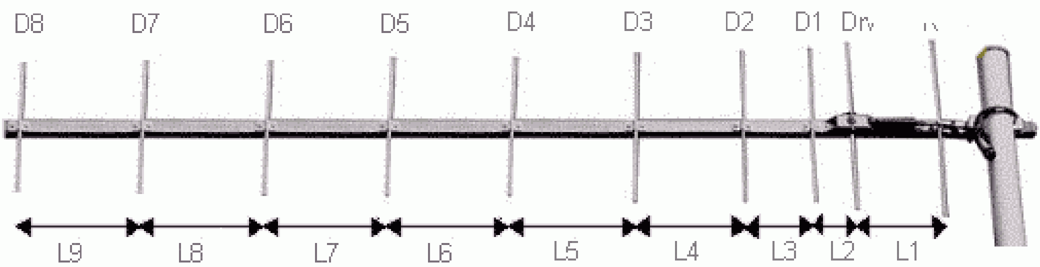


The anode of the 4-400A lights up the Hamshack with a pleasant glow.

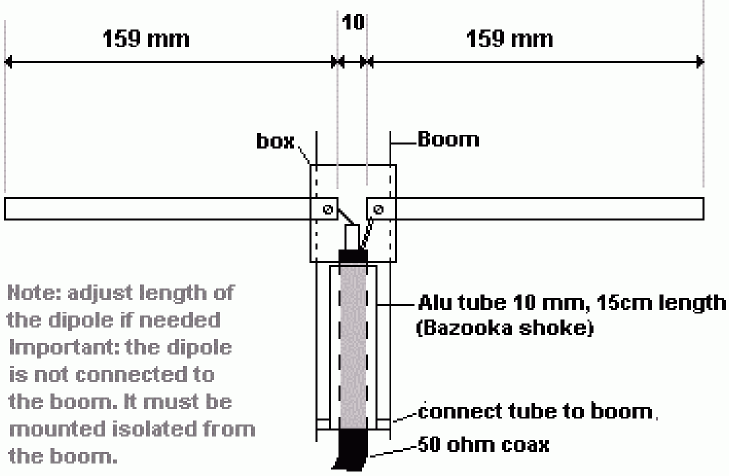
[Home]

10 element UHF antenna

de ON6MU



Technical specs
Forward gain = 11,82 dBd
Front/Back ratio = 22 dB
SWR at 435 MHz = 1:1
Frequency range = 430...440MHz
Horizontal angle = 33°
Vertical angle = 38°

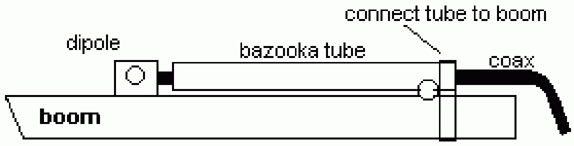


Note: adjust length of the dipole if needed
Important: the dipole is not connected to the boom. It must be mounted isolated from the boom.

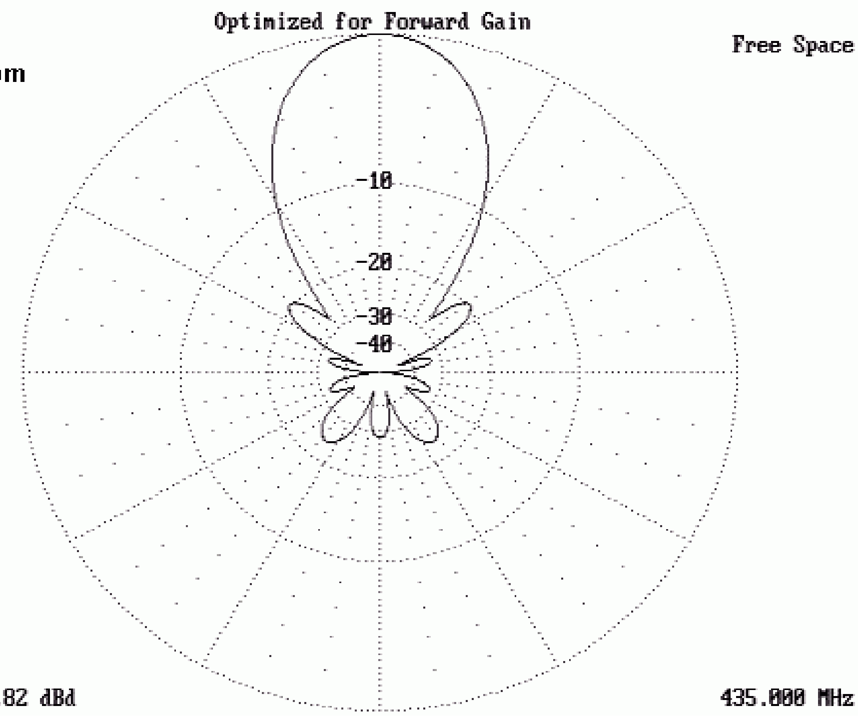
Length of the elements
R = 348 mm
Drv= 328 mm
D1 = 302 mm
D2 = 298 mm
D3 = 292 mm
D4 = 287 mm
D5 = 285 mm
D6 = 282 mm
D7 = 280 mm
D8 = 276 mm

You can also use a folded dipole with a 1:4 balun (see my site for more info about building a balun)instead of a open dipole. To fine tune the SWR (in both cases) by in- or decreasing the dipole length or by moving the dipole between the first director and the reflector a bit. Sometimes it can help by changing the connection points on the dipole (connecting the coax a bit of the center).

Spacing
L1 = 145 mm
L2 = 50 mm
L3 = 124 mm
L4 = 149 mm
L5 = 173 mm
L6 = 194 mm
L7 = 208 mm
L8 = 217 mm
L9 = 225 mm



1.5 meter boom needed



Horizontal stacking distance: 1075 mm
Vertical stacking distance: 933 mm

The elements diameter of the antenna may vary between 5...10mm and the dipole diameter may vary between 8...12mm (12mm recommended) without the need of changing anything to the length or spacing.
All elements except the dipole are electrically connected to the boom and may be mounted on top or through it.
The thickness/diameter of the boom may vary between 10...17mm.
Bazooka tube (RF choke to prevent rf wave currents): not critical, as long as it fits the coax snugly; examples: 15cm long 10mm diameter (for Aircel etc.), 15cm long 15mm diameter (for H100, Aircom+ etc.). Or you can use a few ferrite beads placed over the coax directly behind the driver instead.
Use a piece of isolator type boom (plastic tube, wood, fiberglass) of +/- 40cm if you mount the antenna vertical to prevent distorion of the radiation pattern.
The ideal SWR can vary a bit if the elements are isolated, raised from the boom or do to construction. A bit of experimentation with the driver length can solve this easily.
Note: the antenna can also be tuned between approx. 428...446MHz by adjusting the driver

Images of the 70cm Yagi antenna,
How Greg **SP5LGN** made it

Click to enlarge



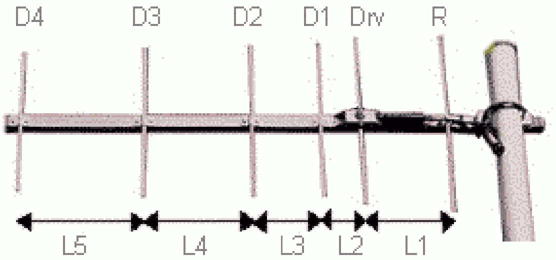



Thanks Greg for the photo's!

Optimized 6-element UHF Yagi Antenna RE-A430Y6

70cm UHF 6ELEMENT YAGI ANTENNA

de ON6MU



Technical specs

Forward Gain = 9dBd
Front-Back ratio = 13dB
SWR at 435MHz = 1:1
Bandwidth = 10MHz
Frequency range = 430...440MHz

Length of the elements

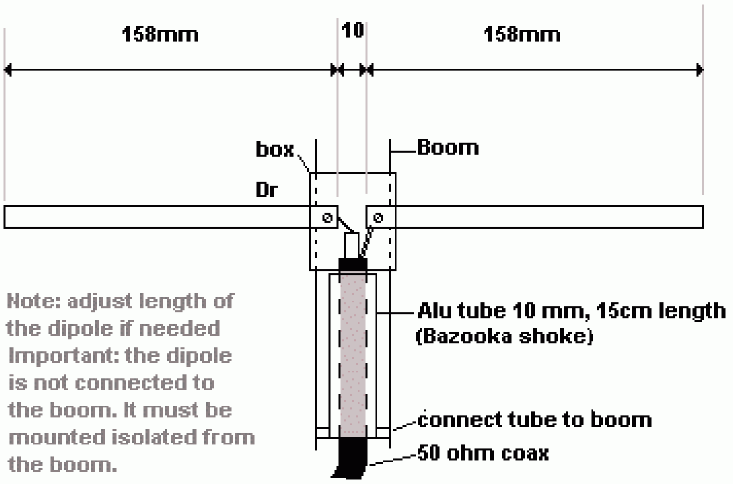
R = 346 mm
Dr = 326 mm
D1 = 302 mm
D2 = 298 mm
D3 = 292 mm
D4 = 288 mm

Spacing of the elements

L1 = 128 mm
L2 = 55 mm
L3 = 124 mm
L4 = 149 mm
L5 = 174 mm

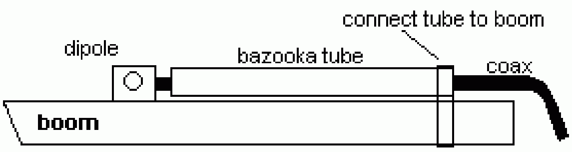
Used material

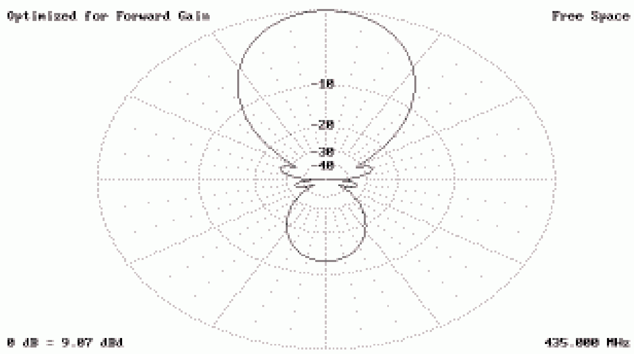
Aluminum tubes of 8 mm Ø
Boom = 15 x 10 mm
15 cm alu tube Ø 10 mm for aircel or RG-58 coax. Use O 15 mm for RG213, H-100, Aircom.



Note: adjust length of the dipole if needed
Important: the dipole is not connected to the boom. It must be mounted isolated from the boom.

You can also use a folded dipole with a 1:4 balun (see my site for more info about building a balun)instead of a open dipole. To fine tune the SWR (in both cases) by in- or decreasing the dipole length or by moving the dipole between the first director and the reflector a bit. Sometimes it can help by changing the connection points on the dipole (connecting the coax a bit of the center).





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All elements except the dipole are electrically connected to the boom and may be mounted on top or through it.
The thickness/diameter of the boom may vary between 10...17mm.
Use an isolator type boom (plastic tube, wood, fiberglass) if you mount the antenna vertical to prevent distorion of the radiation pattern.

Pictures and details of the optimized UHF Yagi antenna 430 Mc to 440 Mhz (420 Mc to 450 Mc @ 1:2 SWR)

- Michel F1SRC and how he made it: http://f1src.free.fr/antenne/yagi/yagi_6el_70cm.htm

-

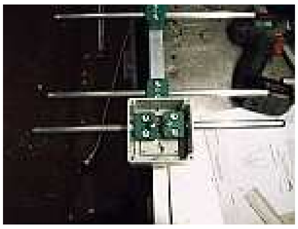
- How Greg SP5LGN made it



Click to enlarge

Thanks Greg.

- How Geert ON3GVG made the antenna:



Note from Geert: he made the driver a few mm smaller to obtain an obtimum SWR in the band segment.
Thanks Geert!

Optimized 4-Element UHF Yagi antenna RE-A430Y4

hamuniverse.com

New To HF? Good info!

Calling All Hams!

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HT Antenna Modification For Increased Performance!

Edited and re-written from an article entitled

"Getting the Most from Your Hand-Held Transceiver"

by

C. Edward Harris, KE4SKY, AEC Fairfax ARES

Also see the HT performance mod by N6JSX at the end of this article for lots more ideas!

When limited to "barefoot" operation, with a "rubber duck", HT antennas are not very efficient nor adequate for communications. They fail miserably as an effective radiator due to their design! They are nothing more than an extended dummy load acting as an antenna!
The following modification will help you to make the most of your HT by increasing the factory antenna's efficiency and the cost is just a piece of wire!

FACTS ABOUT HT ANTENNAS

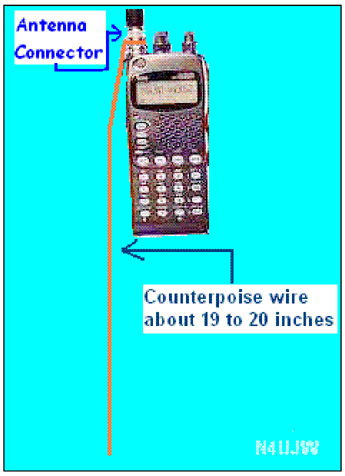
The National Bureau of Standards tests of Public Safety high band and amateur 2-meter antennas indicate that a "rubber duck" has -5db, "negative gain" compared to a quarter wave held at face level. In terms of effective radiated power (ERP), this means that a 5 watt HT with rubber duck, radiates only 1 watt. Operating an HT on your belt results in another -20db attenuation, reducing ERP to 50 milliwatts! That's 1/20 of one watt!
UHF results are no better...

Due to the design of the factory installed HT antenna, you are effectively missing half of the antenna!

MODIFY THAT HT ANTENNA FOR BETTER RESULTS

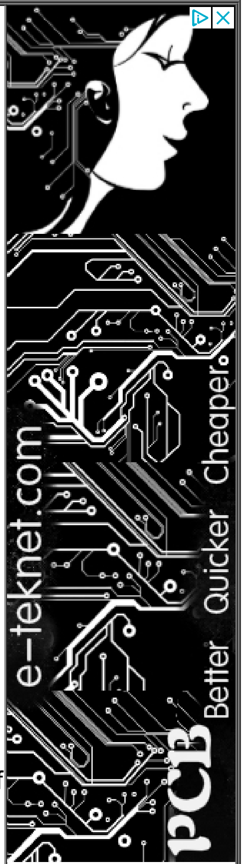
Get ready to use that scrap of wire you have in your junk box!

A simple, inexpensive and effective method to improve a "rubber duck" antenna is by adding an external counterpoise or "tiger tail" thereby adding the other "half".



It should be noted that if your HT is under warranty, the internal modification may void that warranty...you have been warned!

Adding the other missing "half":
You can easily build one from a quarter-wave piece, (about 19.5" on 2m, 11.5" for 220 and 6.5" for 440), of stranded insulated wire, crimped and soldered to a battery clip or use a small spring tension clip that will fit the BNC antenna connector with the wire attached to it. Use a clip or other connection that fits tightly but can be removed if needed. It must make both a good mechanical and electrical connection.



Another method would be to attach the end of the wire by soldering it to a grounded portion of the circuit board inside the HT, although this may not be practical with some models, or any point that is at ground potential on the HT such as the "ground" side of an external speaker/headphone jack, the BNC connector at the antenna, or the Negative side of the battery terminal. The preferred location is at the factory antenna base at the BNC connector. If you have some other type of metal antenna connector the same applies.

Many of the newer models don't lend themselves to internal modifications easily. If the "rubber duck" antenna that came with the HT does not come off, then you will have to make the connection inside the HT to a grounded point. Extreme care must be taken to prevent shorting out other components!!!!!! Use insulated wire. You may have to drill a small hole in the case for the exit point of the wire and tie a knot inside to provide strain relief. Each installation will be different. Use your own judgment and at your own risk!

Always reinforce the soldered connection with heat shrink tubing or tape to resist flex and shorting to other components if possible.
When the counterpoise, (the other half of the antenna), is clamped to the outer collar of the BNC connector on your HT antenna, it helps to prevent RF from coupling with your body, so your completed HT antenna "system" acts much like a center-fed dipole instead of an end-fed dummy load!

You just built a directional antenna and did not know it!
In marginal conditions, extending the counterpoise horizontally and pointing your hand to steer the radiation pattern where you need it, produces a dramatically stronger signal than letting it "droop" towards the ground. Experiment with the angle of the counterpoise to get the best results. In effect, you are creating a form of "V" type center fed vertical dipole with a bit of gain compared to just the factory installed antenna.

If you want to buy another HT antenna, rather than add the counterpoise described in this article, then it is recommended that you shop around. Don't be misled by the cheaper priced antennas. Buy from a reputable dealer that will answer your questions. Try to find an antenna with published gain figures compared to a dipole or 1/4 wave vertical. Don't expect Yagi or similar performance....have fun and get better performance than you were!

The N6JSX HT Antenna Modification

Easy HT Improvements

by N6JSX 09/2013

We all know OEM (original equipment manufacture) HT rubber-ducky antennas are a dismal compromise, at best, facetiously called "*helical-dummy-loads*".There are a few ways to improve your HT'ing distance and experience. First and foremost consider buying an after-market antenna, like the Diamond SRH77CA-SMA or RC77CA-BNC, or make a more economical full 1/4 wave BNC Brass Whip and add a Tail. I found my 2m Brass Whip to work well on 70cm too.

Second, is to improve the antenna's counterpoise; an HT body is a very poor counterpoise! A product I saw decades ago, called the "Tiger-Tail", seemed to have been the answer to this problem but it was just too easy for HAMs to reproduce, killing its sales. The Tail is a 1/4 wave + 5 percent counterpoise wire hung from the HT antenna connector creating a mock 1/2 wave dipole. The trick in making an affective Tail is to insure a good tight fit to the HT connector. I duplicated the Tail by using ring terminals but a problem with ring terminals are those darn BNC posts. I over came this by filing a small notch inside the ring to fit over one post, twist it around the BNC barrel and slip it over the other post. See photo below.

But with the advent of HT's going to a SMA connector the BNC post issue disappears making this Tail a much simpler and far easier to attach.

Notice the new notches in the rings! Cool idea!

The Tiger-Tail is a 1/4 wave +5 percent length of wire hung from the HT connector. Thomas & Betts ring-crimp-terminals:

SMA = 1/4 inch eye for 14-16AWG wire (blue) T&B #14RB-14X

BNC = 3/8 inch eye for 10-12 AWG wire (yellow) T&B #10RC-38X

Black 14-16AWG stranded wire is soldered to the ring.
(I do not crimp my tails but solder the tail wire to the ring terminal.) See Table "A" in the complete download pdf file link below for wire lengths per band.

The hardest part of using this Tail is getting the wire to hang straight. 73~~~ N6JSX

Download the complete pdf file here for the entire project details and enjoy!

Editor note: You may need to get an adapter to go between your exiting ht antenna and the case connector of your ht. The type of adapter would depend on the type connector at the case of your ht and stock antenna bottom end. A good source of adapters and connectors can be found by clicking the banner below!

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L MATCH ATU FOR QRP
by Sean 2E0BAX (Formerly M3FVB)

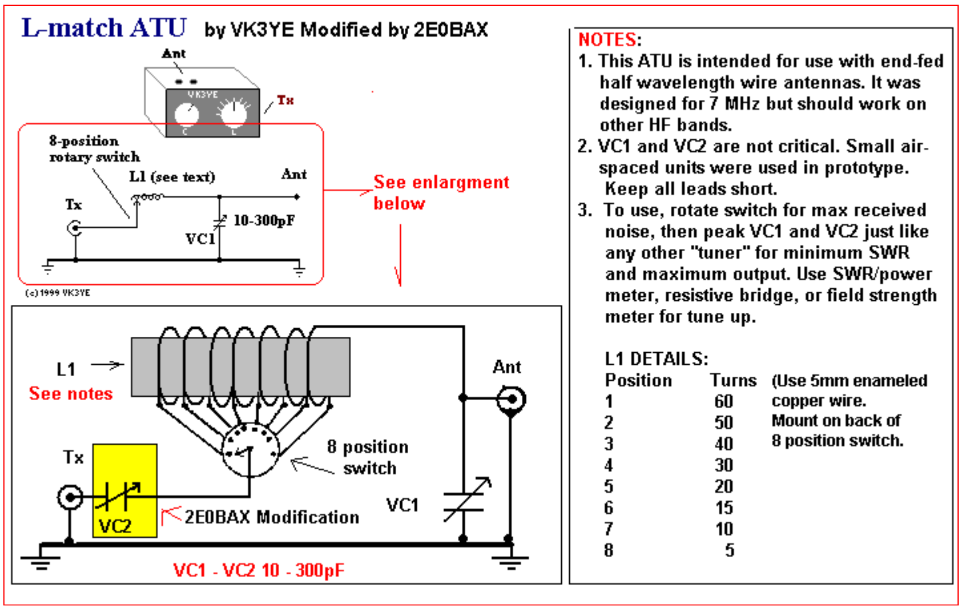
This is phase one of my portable qrp setup where I will be operating from the car in the local hills using the FT 817.

Phase two is the antenna....well that is soon but before I finish the antenna I wanted something to match it with, something that will match 160m - 10m. I already own a very good ATU but its big with a built in SWR meter and it's commercial so its time for something smaller and being used for qrp. I decided to have a go and build one myself.

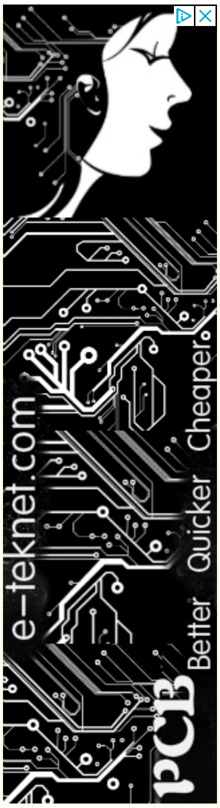
My construction skills are limited but I will have a go and enjoy the experimentation side of the hobby. So in this project I have to use readily available materials and my small collection of tools with lots of imagination.

The L match is designed for the matching of random and long wires and should not be mounted in a metallic box/case. I used a small plastic food container which was the most expensive part of the project. That set me back one pound for 3 or 33.3p for one! The coil was formed around a small length waste water pipe (off cut) and the variable capacitors were robbed from a CB swr meter and matcher...thanks Bernard G3SHF.

Heres the circuit and the pictures below provided with permission by VK3YE. Be sure to check his site out.
He writes articles and enjoys his QRP. Click this link to go there
http://www.alphalink.com.au/~parkerp/

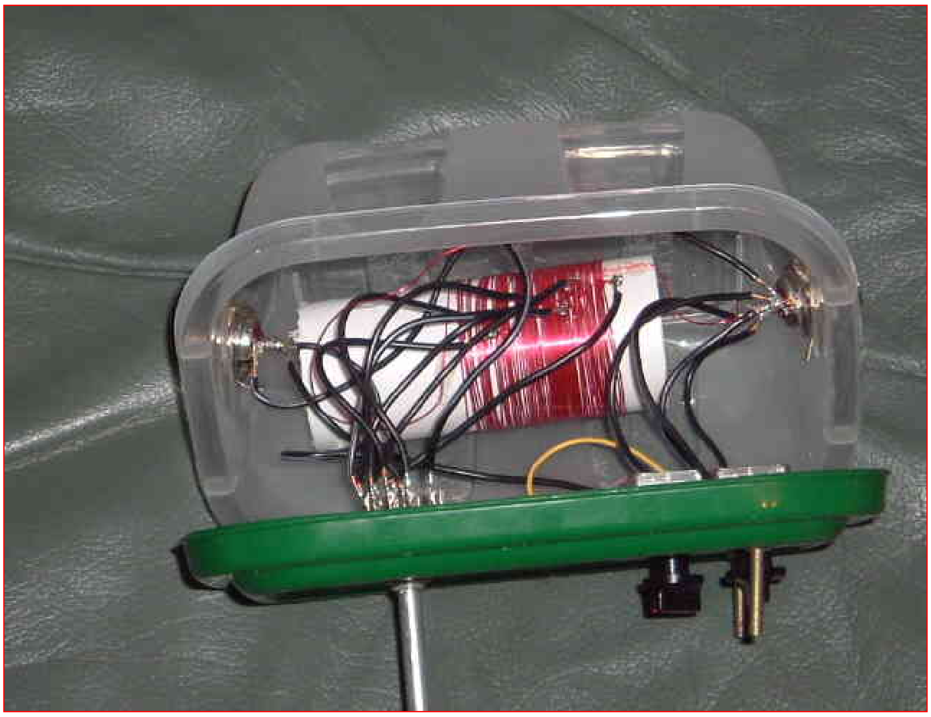


I made a slight change to the original circuit by adding an extra capacitor to the TX side, yellow shaded area in diagram above. It just goes between the S0239 and the switch and allows more bands to be matched.



The top view shows the controls which are Left to Right: The inductor tapping switch (thanks to ROY at work who donated this item and will cost me a pint of cider!) which is requiring a knob at this moment and I have the sore fingers to prove it! Moving to the Right are the two air variable caps with the red markers and sitting above and below these caps is two studs, one for the antenna and the lower one for the earth. I use leads fitted with croc clips to attach to the studs...cheap, simple, easy and its low power.

Heres a side view above and as you can see, there are two S0239 sockets and yes, I know this atu is for matching long wires, however this adds more options and I have found I can match a length coax with a PL259 on it and nothing on the other end. That drooping of the S0239's is caused by the shape of the container, its a design feature HI.



The internal view above shows a lot of wires and ain't a pretty site just as the outside does not resemble an ATU but it WORKS and for me thats all that counts. Spending lots of time playing around with this hooked up to the radio, I found it matches almost anything under an SWR of 3:1 from 160m all the way up to 2m! To me thats a bargain at just over 33p (Oh Yes, the pint of cider Roy) and I'm sorry to say this ATU is not for sale.

Phase 2, the antenna, is not finished yet as of the time of this article and could be another week or two away at the most if not a lot sooner, as I intend to be portable from my car I need to make something for the antenna which will...to be continued!

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The 50 Foot DXE-FTK50 Telescoping Fiberglass Tubing Kit and Antenna Installation Adventure by KF4WRL

My installation and modification of the DX Engineering DXE-FTK50

Some history about why I did the modification.

We took a lightning hit several years years ago when my son Ced was fooling around with a metal 5/8 wave, 11 meter antenna, on a push-up pole, about 40' above grade. The co-ax was disconnected, and laying on his bedroom floor. We were "counting" lightning strikes, approaching from the southwest. "ten...six...three...BOOM!". It came firing out the side of the co-ax. I've learned that lightning is high frequency, and doesn't like to turn corners. The EMF took out two TVs, two phones, and a "Billy Bass", hanging on his wall. So I devised a method for lowering and raising my 41 foot vertical inside the 50 foot tubing kit (shortened) made by DX Enginnering. An ounce of protection is worth a pound of cure!

History lesson over....read on....
The 50 foot fiberglass tubing kit DXE-FTK50 from DX Engineering came with seven 96" telescoping sections. I wanted to install my wire vertical inside the tubing and raise it up and down from the ground to help with lightning protection in the future.

The smallest top section of the 50 foot kit is too small to accept my vertical wire of 41 feet, and it's too flexible, anyway. The instructions that came with the kit advised guy ropes. I've decided to dispense with them because my tiny yard limits that and I'm trying to fly beneath the radar of local codes that forbid antennas in the front yard, hence the bamboo camouflage growing in the background in the first picture on the left below. So far it has withstood 23 M.P.H. winds, on a couple of occasions.

The photos above showing the large pulley-wheel on the left that became prototype #1. It didn't work well at all. I did some creative PVC heating, stretching and shaping, to accept a much smaller wheel (pulley) as seen on the right photo above and in the closeup photo below.

Smaller pully wheel installed

I used to work at a place called Southern Industrial Supply Co. (SISCO) where I learned that when you heat PVC to a temp above 142 degrees, it becomes "leather soft". I also learned to stay up-wind because of the toxic fumes. The guys in the fab shop at SISCO warned that if you can smell it, you're getting too much so use caution if you attempt this method!

I'm running a Yaesu FT-950, through an MFJ-989b roller tuner. About 20' of co-ax gets me out to the 4:1 LDG balun at the base of the 41' vertical wire shown below.

"Radial Ring and base of vertical with balun"

A ring of #6 AWG solid copper wire serves as the radial "plate" seen above. The radials are limited in length by proximity to the lot line on one side and a sidewalk/patio on the other side. There are only 8 now but I plan to add more in the future. I'm guessing that if folks can talk DX using the roof of a car for a counterpoise, I can eventually get my radials dense enough to suffice and feel safer about lightning.

73 - Race KF4WRL

Email him for questions at >>>>>> rharris282 AT tampabay.rr.com

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From Junk to the Super Scanner Antenna on 10 Meters!

Modify an 11 Meter Super Scanner Antenna for 10 Meter Use

By Ken, KD0AGV

With special credit to Bill O'Connor, who lives near Harrisburg Pa. Without his help, this project would never have gotten this far!

View of completed antenna

Many years ago, the Super Scanner Antenna M-119 by Antenna Specialists was a very popular antenna for 11 meter use. It was designed as a "compromise" antenna with the properties that made it into an antenna that was somewhere between a beam and a ground plane type antenna. The "beam" property of the Super Scanner was the result of electronically rotating the pattern rather than using a rotor.

The omni directional property and "beam" effect was designed into the controls and phasing, enabling the antenna to be used as a "beam" (sort of), or it could be "switched" into the omni directional pattern.

This fit the needs of many thousands of CB'ers who did not have the room for both types of antennas! The resulting pattern of it was in 3 major lobes spaced 120 degrees apart giving an almost circular pattern. The switching of the lobes was accomplished by a control box near the radio which sent signals to a relay box at the antenna which cut in or out various relays and phasing lines to accomplish the pattern change.

According to various sources, the antenna had an "impressive" 5.75 dbi gain in the omni mode and an 8.75 dbi gain in the directional mode. These "gain" numbers really impressed a number of people who used them compared to regular ground planes and the numbers especially impressed those that could not have a beam for one reason or another. Of course, those of you who know a bit about gain figures see that the numbers are based on "I" isotrophic rather than "d" for dipole which is the standard reference antenna! So to many CB'ers, they saw some BIG numbers in those "gain" figures.

This project should be only considered by experienced antenna builders who are familiar with reading schematics, soldering, using electronic components, work well with hand tools and have lots of mechanical ability in order to fabricate the various brackets, mounting arms, coax assemblies, etc. It is in no way meant to be a step by step instruction guide but to give you the basics behind the construction of the antenna. You will have to leave much to your "ham ingenuity".

Here we will show you how to duplicate the construction of the Super Scanner antenna modified for 10 meter Amateur Radio use by using a Super Scanner antenna calculator and a formula that we discovered by experimentation!

A bit of background first. The original CB band (23 channels), covered from 26.965mhz to 27.255mhz (290khz wide), back when this antenna was very popular, so the Super Scanner was designed for this band of frequencies and not 10 meters.

This project has attempted the design for use over the entire 10 meter ham band which is 1.7mhz wide! It "favors" the low end of the 10 meter band with lowest swr around 28.000mhz to 28.300mhz with a 1.3 - 1.4 to 1 swr over that range. On the high end at 29.100mhz to 29.700mhz swr was 1.8 - 1.9 to 1. Your end results may be different depending on your design!

In the Omni mode I got a flat 1.2:1. The single vertical sections give a little higher SWR. Ive found it tunes up quite easy.

The Scanner design program from VE3SQB was used for the lengths and spacing of the various elements, support arms, etc. [Download and save it here](#)! You will need it!

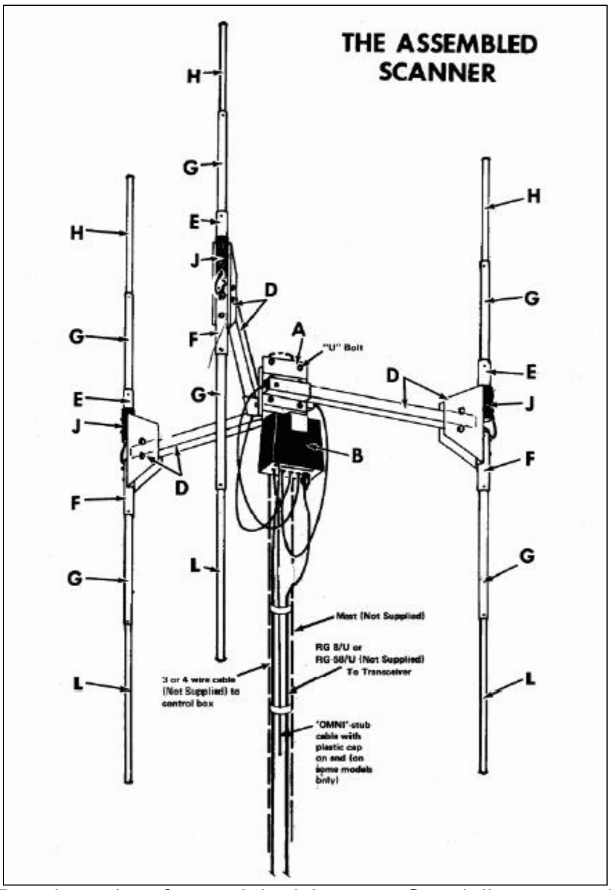
A workable formula below was derived by experimentation for the phasing coax lengths from the relay box to the individual elements due to the fact that there were no calculations in the VE3SQB program for the phasing line lengths!

This formula appears to work well:
220/freqmhz = length in feet for each phasing line using RG-58 coax

Example: 220 / 28.500mhz = 7.71 feet = 92.63 inches. (round off to 92 1/2 inches)
Editors note: We tried this formula for finding the original phasing line lengths on an old Scanner antenna used in this project using the low end (channel 1), frequency of the CB band and came up with the exact length that was used on the CB band version. We have no idea why Antenna Specialists used this length! But using the formula above gives us the same length as the mfg used on the original antenna....so it does work.
You will also need to refer to the original instruction manual. You can download it at the link below. They are in pdf file format.

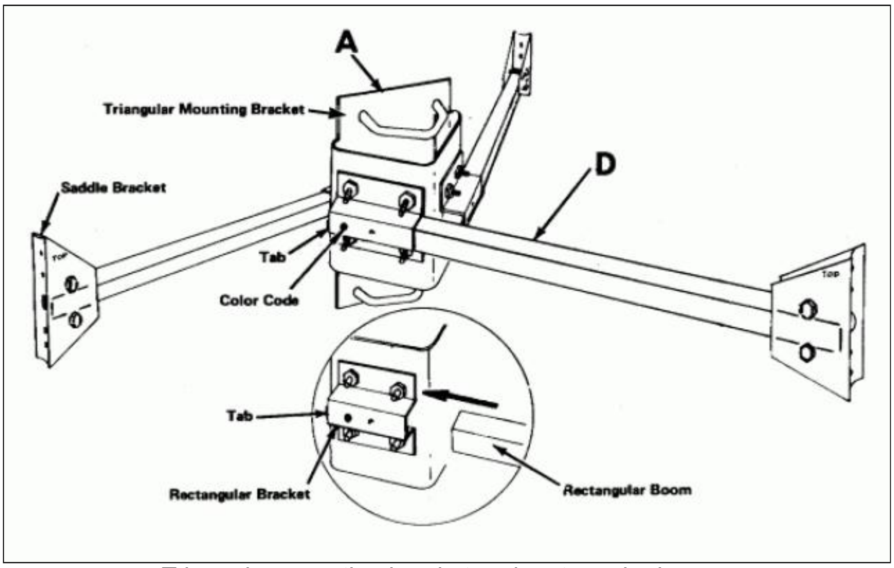
http://www.scribd.com/doc/3359466/superscanner

Unless specified, all drawings below were taken from an original instruction manual for this antenna designed for 11 meter CB and are for reference only to give you some ideas as to your construction.

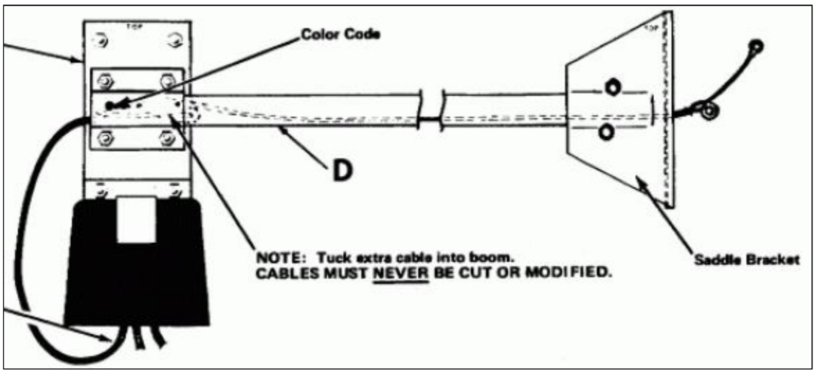


Drawing taken from original Antenna Specialists manual
The overall layout. Not to scale!

In the drawing above, there are three vertical dipoles each oriented 120 degrees around the center section and insulated from and mounted on individual boom supports. The supports are mounted to a triangular bracket that is attached to the mast with "U" bolts seen in the drawing below.



Triangular mounting bracket and rectangular booms

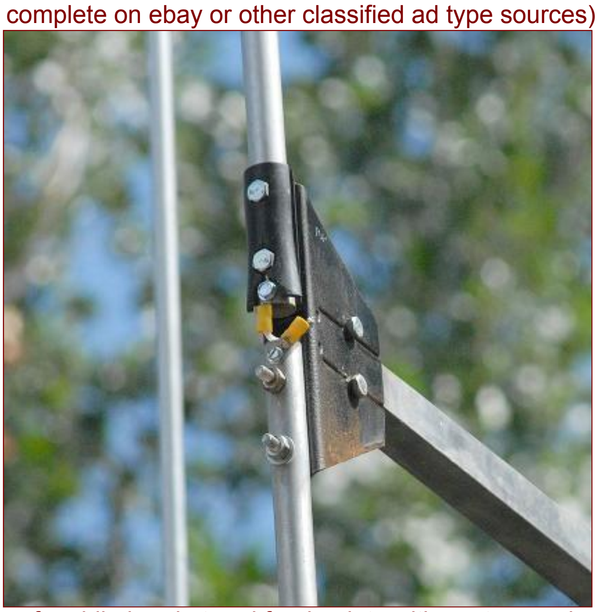


The relay box shown above containing relays, the phasing line connections and switching connections, is mounted at the bottom of the triangular mounting bracket.

Refer to the pdf file instruction manual in the links above for the schematics of the relay box and the control box.

Original Control Box 19-2425

(If you are in luck, you may find an original relay box and the control box complete on ebay or other classified ad type sources)



View of saddle bracket and feed points with center conductor of phasing line connected to top half and shield to bottom half. Note the insulator on the top half keeping it away from the bracket!

Side view of saddle bracket, insulator and support arm

Additional notes and information:

The tips of the antenna were about 4' off the ground for the swr measurements.

The relay box on the antenna is the mfg part number,19-1921. It only uses 2 relays, the measurements I took for the coax was from the plate where the coax enters the relay box to the end (at the 92.75 mark, I left about 1.25 inches to strip back and connect). The coax is RG-58/U solid center. It is easier to work with. The vertical sections are made up of three pieces. I slid the bottom and the top piece into the center section, drilled one hole and used new self tapping screws in place of the old screws. Everything else is stock from the original antenna.

The arms are 1 square aluminum (it's carried at Lowes). The original length of the arms is 38.5. I removed 2 inches from the arms. Also you need to be careful with the plastic isolators (top sections). The end of the arms are re-enforced with steel inserts (about 2 inches long, 1/16 steel). The aluminum arms need to be strong enough to prevent twisting of the vertical elements. I would either get the thickest walled aluminum you can find or re-enforce the aluminum with some other metal. When attaching the coax to the vertical sections, (SOLDER SPADE LUGS) to the coax.

If the antenna is subject to windy conditions, guy it below the cross arms using non-conductive material strong enough to do the job.
Get help putting it in the air and stay well clear of power lines!

Keep metal guy wires below the lowest end of the antenna or break them up about every 7 feet with insulators.

The phasing lines, connections on the relay box, control box and the cross arms must be color coded in such a way in order to know that the element directions match up with the control box directional control! See the instruction manual.

Further Experimentation!

Initial experimentation with the Super Scanner 10 meter modification was using vertical polarization.
Ken is in the process of further experimentation using the antenna in the horizontal position with a rotor. The unique mounting method simply "flips" it from vertical to horizontal polarization. See pictures below:

Supper Scanner mod in horizontal position using unique 90 degree mounting.
(Shown with rotor attached for "aiming")

Mounting method for horizontal polarization using 90 degree bent into mast.
(Rotor is out of picture below the 90 degree bend)

Initial on the air results in the "low" part of the Solar cycle and poor band conditions are very good and the antenna is much less noise prone. 73, Ken KD0AGV

Questions:
For more information about this project,
Email to Ken - KD0AGV - fullofblarney at comcast dot net

Editors note:
Our hat is off to Ken, KD0AGV, for all his hard work (fun) in putting this project together for all to enjoy. It's hams like himself that make this "hobby" great.

Thanks Ken! 73, Don N4UJW

A 400 Watt 60 Hertz Power Inverter

by W5JGV

August 15, 2005 *(revised August 18, 2005, July 19, 2006)*

What To Do With Those Old Buzz-Box (Vibrator) Inverters.

Over the years I have found that having a 12 Volt DC to 120 Volt 60 Hz inverter is quite useful. I occasionally make repairs to equipment in areas where there is no available AC power to run my power tools. Having an inverter that I can connect to the car battery is a real lifesaver. Yes, I know that there are lots of battery operated power tools out there, and as a gadget freak, I certainly own my share of them. Sometimes, however, it's just easier to be able to run a more powerful tool, soldering iron, electric drill, or whatever, and a good inverter fills the need. The problem is that some of the more modern power inverters are not capable of running a serious power tool.

Digging under the tables at Hamfests will often reveal discarded or deceased square wave vibrator inverters, or early model transistorized inverters, such as the one I show in this article. These units are excellent candidates for conversion to transistorized operation. What I will show in this article is a way to convert one of these older units to fairly stable 60 Hz (60 Cycle to you old guys, like me!) transistorized inverter with overload characteristics similar to the old vibrator driven inverters. This particular unit shown in this article is essentially a vibrator inverter which has been converted to transistor operation. You can convert any inverter of this type or a vibrator inverter according to this article and it should work just fine. Note that the newer "build a waveform" inverters use very small transformers and are not suitable for this method of conversion - they don't operate on the same principle.

The use of transistors in power inverters has greatly changed the internal design of power inverters. The first inverters available in the 1940's used a vibrator to drive a transformer to convert 6 or 12 Volts DC to 110 Volts AC. The vibrators used in these power inverters are the big brothers of the smaller 4, 5 and 6 pin plug-in metal can vibrators used in car radios of the 1940's and 1950's. These power vibrators came in larger sizes and could handle substantially more power then their smaller kin.

The internal design of the vibrator inverter is fairly simple. DC comes into the unit, and is chopped into square wave pulses by the alternating contacts of the vibrator, which acts as a single pole double throw switch. These pulses are then fed first to one end of the center tapped primary winding of the inverter transformer, and then to the other end of the primary winding. This alternating series of DC pulses simulates an AC square wave which the transformer steps up to 120 volts AC on the secondary side. The power limit on this type of inverter is usually how much current the inverter contacts can handle before they melt. (That happens more than you would expect.)

In normal operation, the oxide film on the Tungsten vibrator contact surfaces and the bulk resistance of the contacts causes a small voltage drop across the contact points when they are closed and carrying current. This drop is in the order of 0.05 to 0.20 volts, depending on the current and condition of the contacts. Since the vibrator assembly is built into a closed and soundproof case (there's a reason we called 'em Buzz Boxes!) to prevent contaminants from entering the vibrator case and damaging the contacts, it's hard for heat generated by the contacts and the vibrator coils to escape. Because of this, the vibrator is usually rated at somewhat less

current that the contacts can ultimately handle. However, the vibrator can intermittently handle some current above it's normal rating if the operator is careful. Fuses are absolutely essential with a vibrator inverter, because since the vibrator is just an oscillating switch, it will try to pass whatever current the load is demanding. That's why the vibrator inverter is so nice; you can run anything on it as long as you don't cause a meltdown.

Present day power inverters are much smaller in physical size, and they can handle a lot more power than the older vibrator driven units. However, I have found that many of the new inverters are unable to handle much of any overload without "dumping" and shutting off. For example, trying to run a 14" color set on a 300 watt rated inverter resulted in the inverter shutting down on overload. The TV set is rated at 120 watts, and the inverter is rated at 300, so what's the problem? Well, when the TV set is turned on, it draws a big surge of current to charge the filter capacitors and operate the degaussing coil surrounding the picture tube. This surge shuts down the inverter. An old style vibrator driven inverter will just grunt a bit and then carry on, starting the TV and running it in fine fashion.

I have a large Radiart vibrator that is in a case that measures about 5" x 3" x 3" in size. It has two 6-prong plugs on it to handle the power. It is driven by two electromagnets and requires about 25 watts at 12 Volts DC just to run it. It has a total of 16 switching contacts, not counting the contacts used to drive the vibrator coils. It's a real beast of a vibrator, but it can handle the power! I use it in the original inverter, which was rated to handle 300 watts - at 6 volts! That's a current drain through the contacts of about 50 amps! Not bad for a buzzing relay.

I discovered that the transformer was actually made with 4 -6 volt windings in parallel, so I was able to reconnect the transformer to make it work on 12 volts. I found that the transformer had enough iron in it to handle more power, and I found that I could now get up to 600 watts out of the unit. Remember what I said about meltdown? Well, I found that with that big vibrator, I could actually run my 6" circular saw from the inverter. Not for too long, though, but it is still impressive. None of my newer transistorized units will do that.

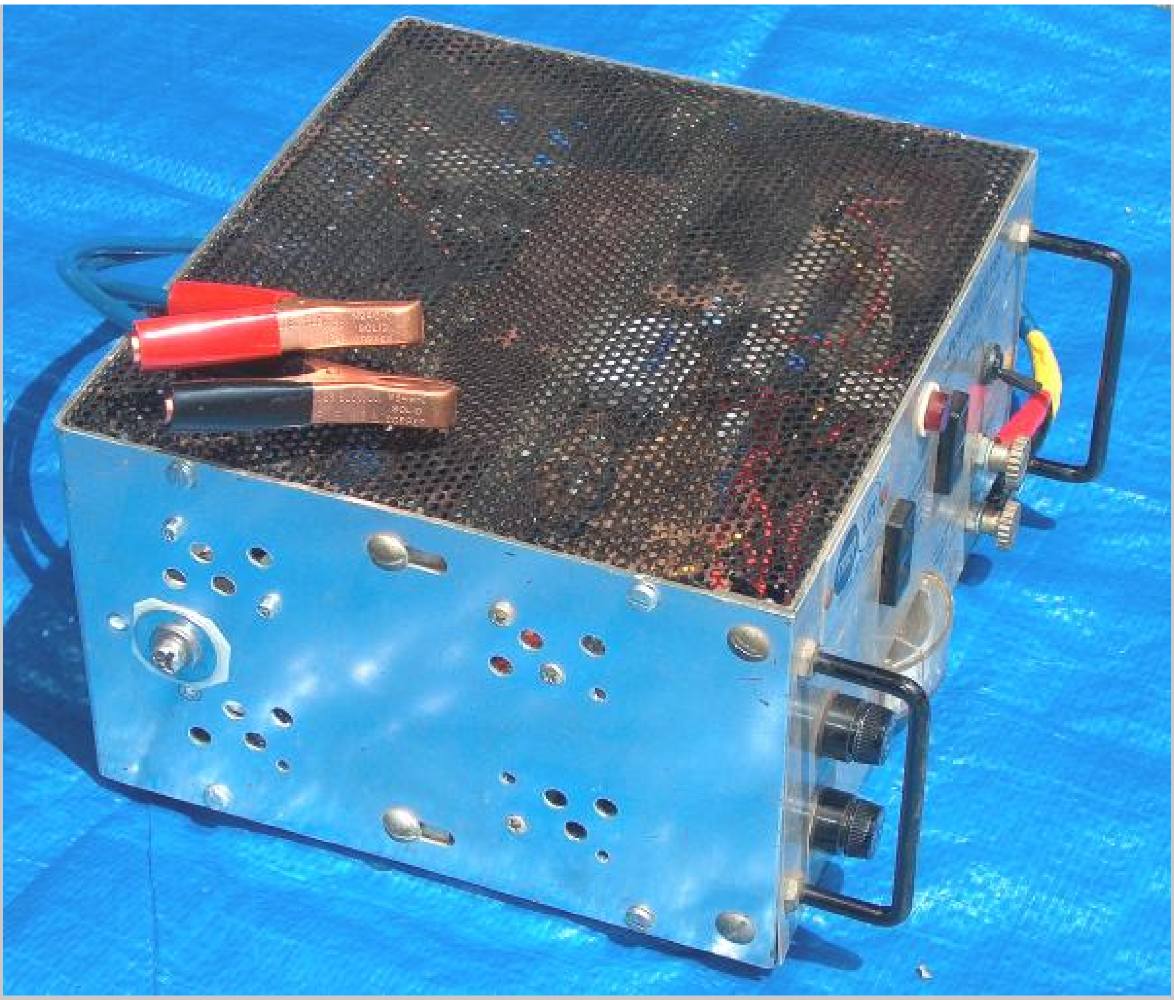
Still, one day, the vibrator will expire, and then I'll have to figure out something to replace it with or scrap the unit. This particular vibrator is no longer available. It cost me better than $50.00 USD back in the early 1950's; I hate to think of what it would cost today, if it were still available. The logical option (these days, anyway) is to think "Solid State!"

Modern inverters use a bunch of transistors to replace the vibrator. There are three types of units commonly available. One type "builds" a sine wave out of high frequency pulses which are summed into a sine wave by a transformer / low pass filter system. These are used for loads that require actual sine wave power. Most equipment is not so critical as to their power requirements, and they may be operated on what is termed a "Modified Sine Wave" power source. This is usually a square wave AC waveform, with a long dead time between the positive and negative portions of the waveform. The result of this waveform is to greatly reduce the harmonic content of the waveform as compared to a simple square wave. The third (and earliest) inverter simply generates a square wave output. Most, but not all, devices will operate satisfactorily on a square wave. In addition, square wave inverters are simple to build when compared to sine wave or modified sine wave inverters.

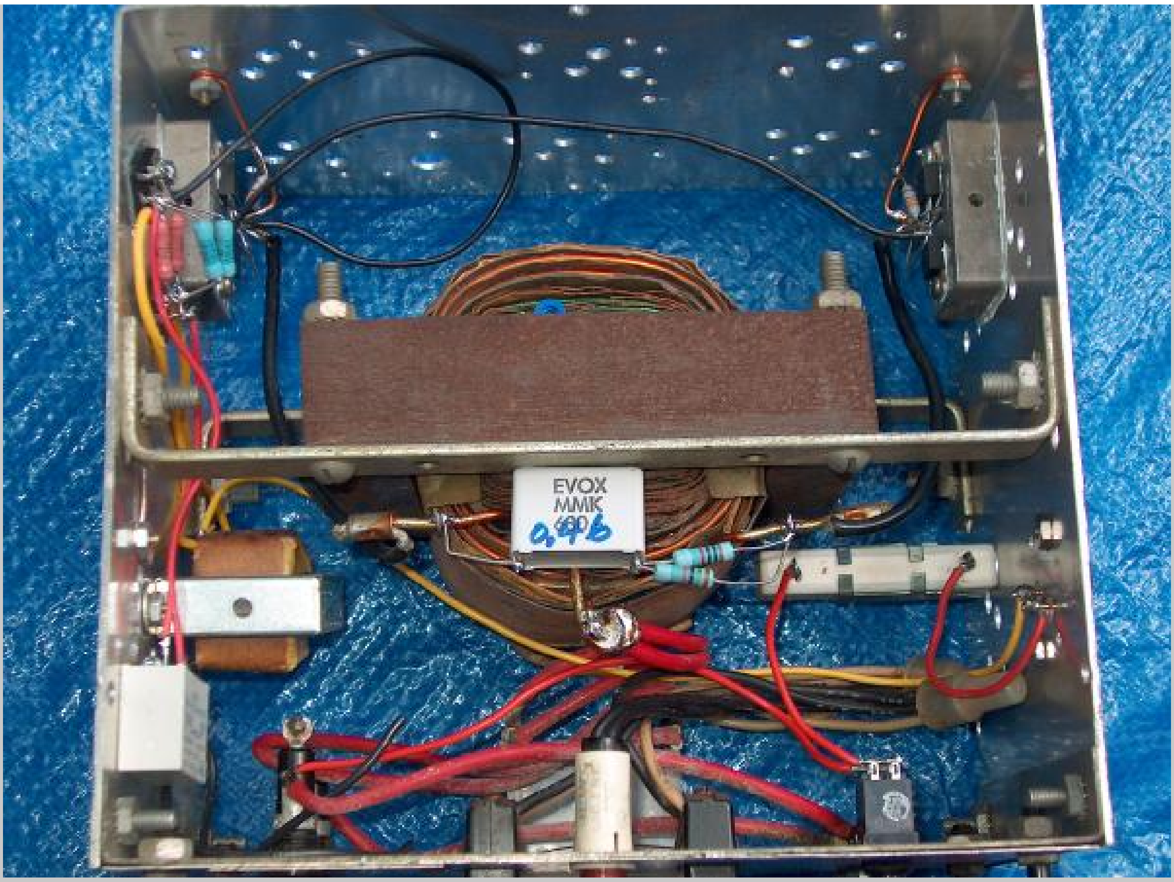
The conversion described here will result in a square wave output, which is what these older vibrator / transistorized inverters produced originally. I've converted four of these units so far, with excellent results in each case. One advantage of converting these units is that they are much more electrically quiet than the vibrator units. The contacts in a vibrator inverter always exhibit some amount of sparking and that sparking causes RFI. Noise suppression is accomplished in these units by using carefully chosen high voltage buffer capacitors placed across the transformer windings and sometimes across the vibrator contacts as well. Failure of a buffer capacitor - they always fail shorted - often results in a set of melted vibrator contacts. After conversion as shown in this article, RFI is a thing of the past, unless you do a poor job of construction. In that case, it is possible for the MOSFET's to oscillate at VHF and cause interference. That problem is easily solved by placing a very small ferrite bead over the gate leg of the MOSFET's.

This was a nice on-the-table Hamfest find - a 400 watt combination inverter / battery charger. The fellow who sold it said he could not find replacement transistors for it, so he was selling it to clean out the shack. As it was originally designed, it used a total of 10 PNP TO-3 power transistors to handle the 12 Volt DC power and generate a clean square wave output at 117 volts 60 Hz. The transistors were toast, and a replacement set would cost over $100.00 USD, so something else was definitely in order! The transistors were also used as the battery charger rectifiers, but since the voltage regulator circuit was missing when I obtained the unit for $5.00 USD, I decided to strip the unit and start over. This picture shows the unit after conversion. I did not bother to paint it or dress it up, as it will be a "workhorse" unit used in the field.

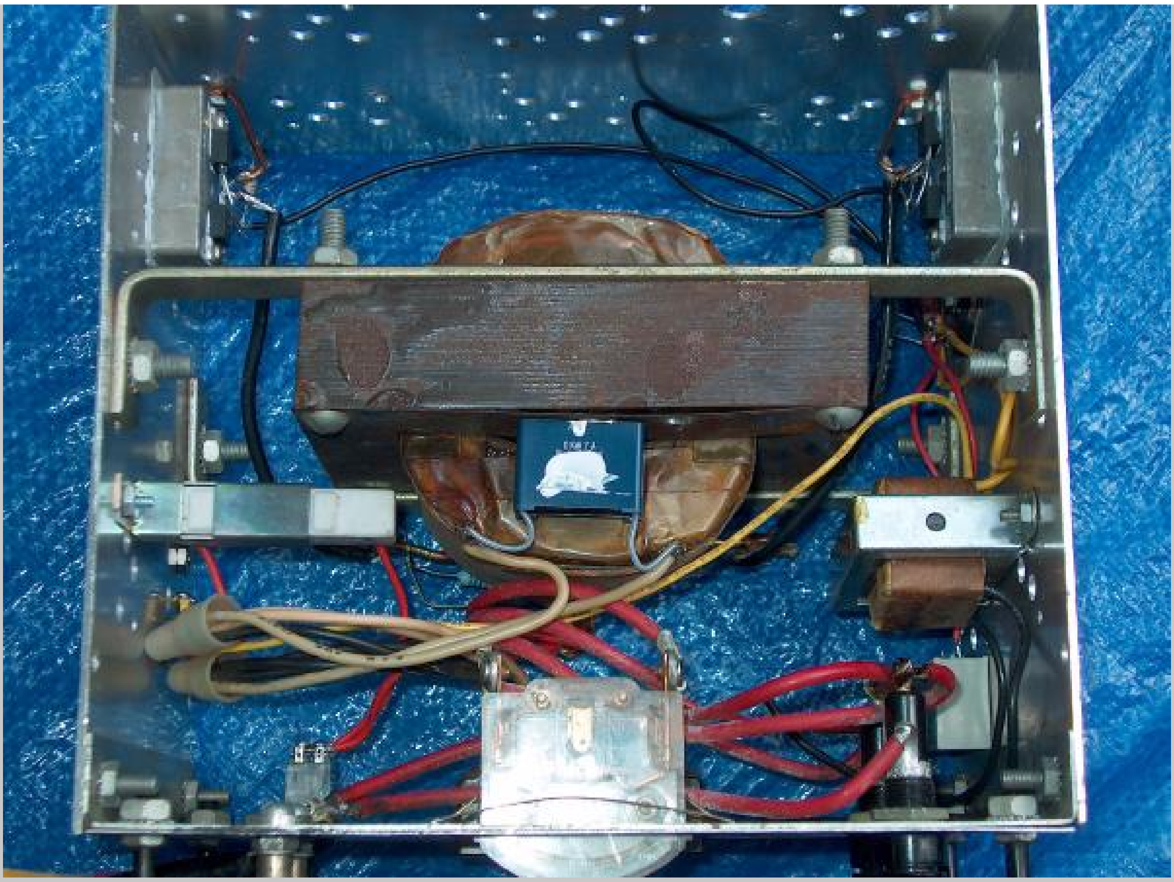
What I decided to do was to replace all of the PNP transistors with some high power MOSFET transistors which have very low voltage drop when they are turned on. In that respect, they behave much like a vibrator. By using high current rated transistors, excellent overload capacity is available. The required square wave gate drive for the MOSFET's and the 60 Hz frequency control is provided by a low power cross-coupled oscillator using a small filament transformer that is driven into core saturation.



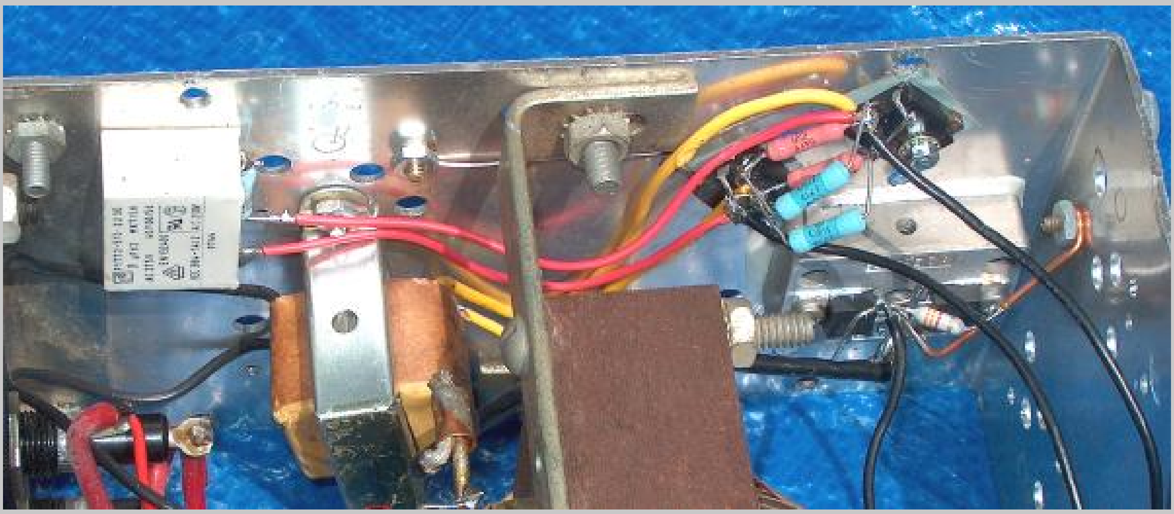
This view of the modified inverter shows a 1/4" diameter bolt and washer near the rear (left) of the cabinet. The bolt holds an aluminum block against the chassis for cooling. A pair of MOSFET's are mounter on the thermal block. Note the white plastic electrical insulation between the washer and the chassis. The bolt is electrically "hot" because it is connected directly to the cases (drain connection) of the MOSFET'S.



Here's a top view of the modified inverter. In the center is the output transformer. Since it if used at 60 Hz, it is big and has lots of iron in the core. Newer high frequency inverters will have very small ferrite core transformers in them. Note the heavy gauge wire of the primary winding, which is wound over the high voltage secondary winding. The four power MOSFET's I used in this conversion are mounted in pairs on the rectangular aluminum heat spreader blocks which are visible to the left and right of the case. The primary winding snubber RC network is visible as the "EVOX-MMK" capacitor and the two blue resistors to the right of the capacitor. The small transformer mounted on the left side of the chassis is the oscillator transformer. The snubber network are required to handle the energy stored in the leakage reactance of the output transformer. If the snubbers did not eliminate this energy, potentially destructive high voltage spikes can occur during the switch time and destroy the MOSFET's.



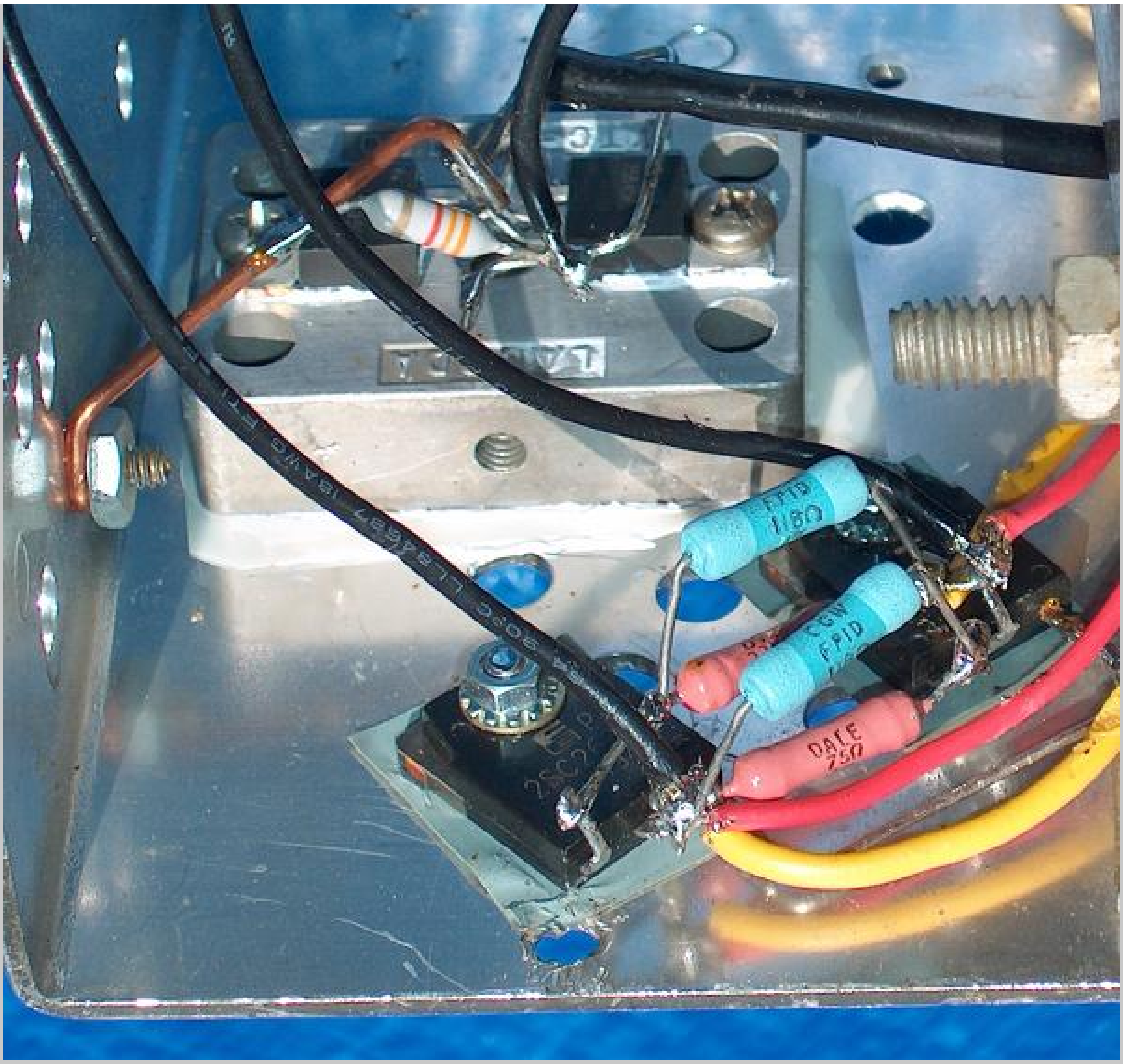
Bottom view of the modified inverter. The blue capacitor with the white paint on it is connected across the secondary winding to clean up the waveform. It reduces the high frequency secondary ringing to a lower frequency and reduces the amplitude of the ringing. I used the ammeter which was part of the original unit (the meter is visible in the lower center of the photo) as it is handy to be able to check the load current drawn by the inverter. The two original POST style 3AG fuse holders were left in place and used in this conversion. They each contain a 20 A fuse. They are placed in parallel. If I were to build a new unit, I would have used the newer and less expensive automotive fuseholders and fuses.



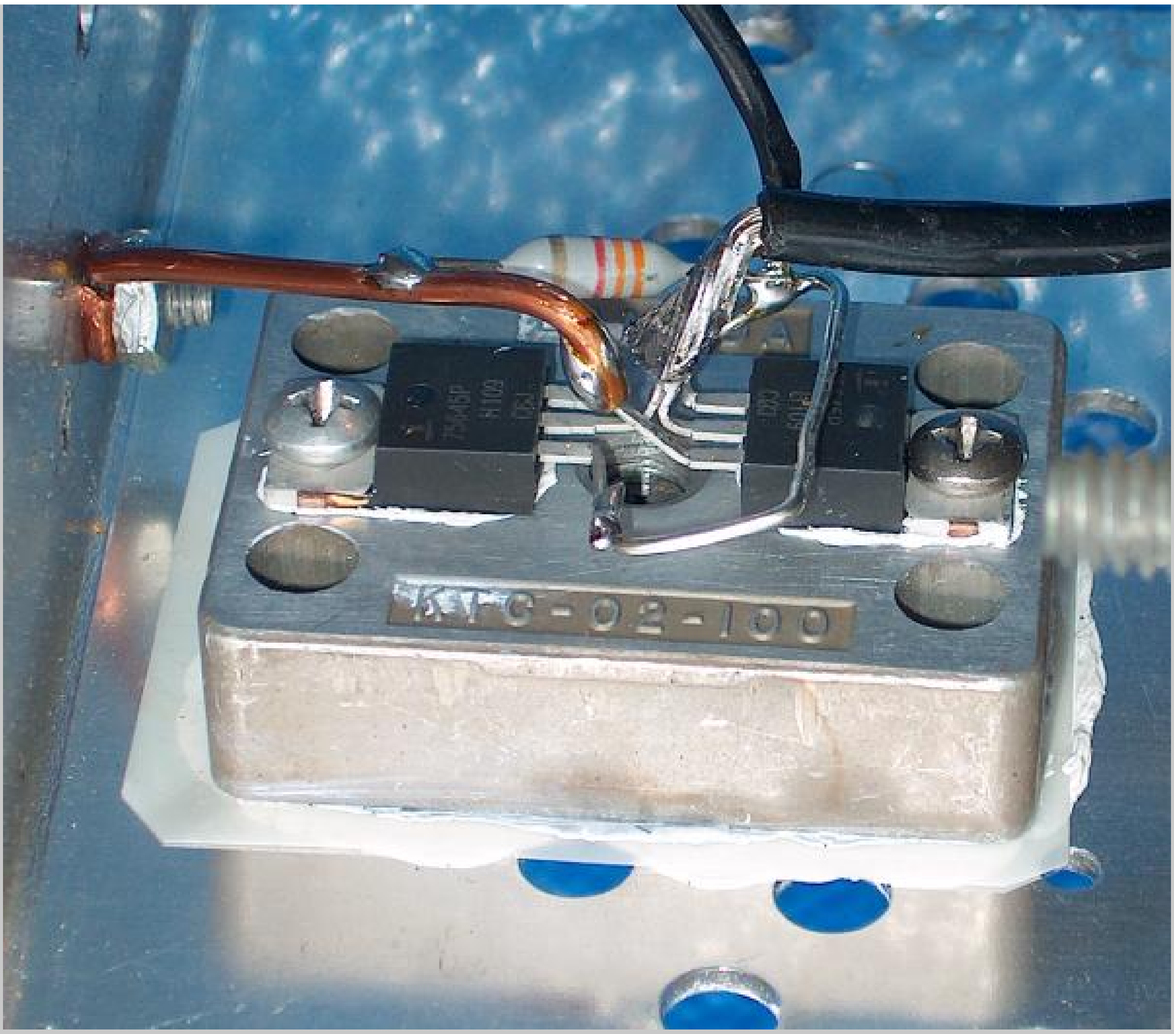
This is the oscillator. The filament transformer is driven to saturation at a 60 Hz rate by the pair of NPN transistors mounted just above the heat spreader block for the MOSFET's The red and blue resistors set the base drive for the oscillator transistors and adjust the frequency of the oscillator.

Keeping the oscillator DC supply voltage steady is necessary in order to maintain the frequency at exactly 60 Hz. A 50 watt Zener diode is used to regulate the supply voltage. Zener diodes can hold voltages more accurately than most 3 terminal voltage regulators. Since this Zener diode was already in the unit when I obtained it, I decided to make use of it. The large rectangular white resistor (salvaged from an old TV receiver) provides current limiting for the Zener diode. With the component values shown on the diagram, the gate drive and the output frequency is constant at all DC input voltages from 8.5 to 16.5 Volts. The Zener diode is mounted on the other side of the chassis where the red and yellow wires are soldered to the diode pins.

The case of the Zener diode is grounded to the case, but I used some heat sink compound between the case and the chassis to ensure good thermal contact. Because the oscillator frequency is determined by both the DC supply voltage and the base drive of the oscillator transistors, the Zener diode was used to hold the oscillator supply voltage constant. (More about this in the schematic discussion.)



Here's a close up of the oscillator transistors and the one of the MOSFET pairs. I can't say much for the neatness of the solder joints, but they are secure. I think I soldered, unsoldered, and resoldered a zillion resistors until I found the ones I needed to get the correct frequency. Note to self: Next time, use a potentiometer!!! The transistors are insulated from the chassis with some thermally conductive insulators I salvaged from some old computer power supplies. The transistors also came from computer power supplies. In fact, so did the nuts and bolts I used to mount the transistors to the chassis. Computer power supplies and computer monitors are a treasure trove of small parts for homebrewing electronic equipment!



Although the diagram shows a pair of MOSFET's in the output circuit, there are actually four transistors used. Each end of the output transformer is driven by a paralleled pair of MOSFET's. Note that they are mounted as a parallel pair on an aluminum block. The Drain (case) of each transistor is bolted directly to the block with no insulators. This is to maintain the temperature of each transistor in the pair as identical as possible. Maintaining identical device temperatures allows the transistors to more closely track each other electrically when in operation. The aluminum block is electrically insulated from the chassis by a section of plastic sheet insulator that was salvaged from a computer power supply. I tested it for good heat transmission, and it was adequate for this job.

Each of the MOSFET's used here can handle at least 65 A, so a single pair should be sufficient to do the job in this inverter. Why did I "double up" on the transistors? The voltage drop across a MOSFET (the conduction loss) when it is switched on increases in proportion to the current passing through the MOSFET. Placing two MOSFET in parallel, causes each one to carry just half of the total current. The forward current voltage drop in a conducting MOSFET has a positive coefficient of temperature. This means that as the MOSFET gets hotter with increasing current, the internal resistance of the MOSFET will increase, which then increases the voltage drop across the MOSFET.

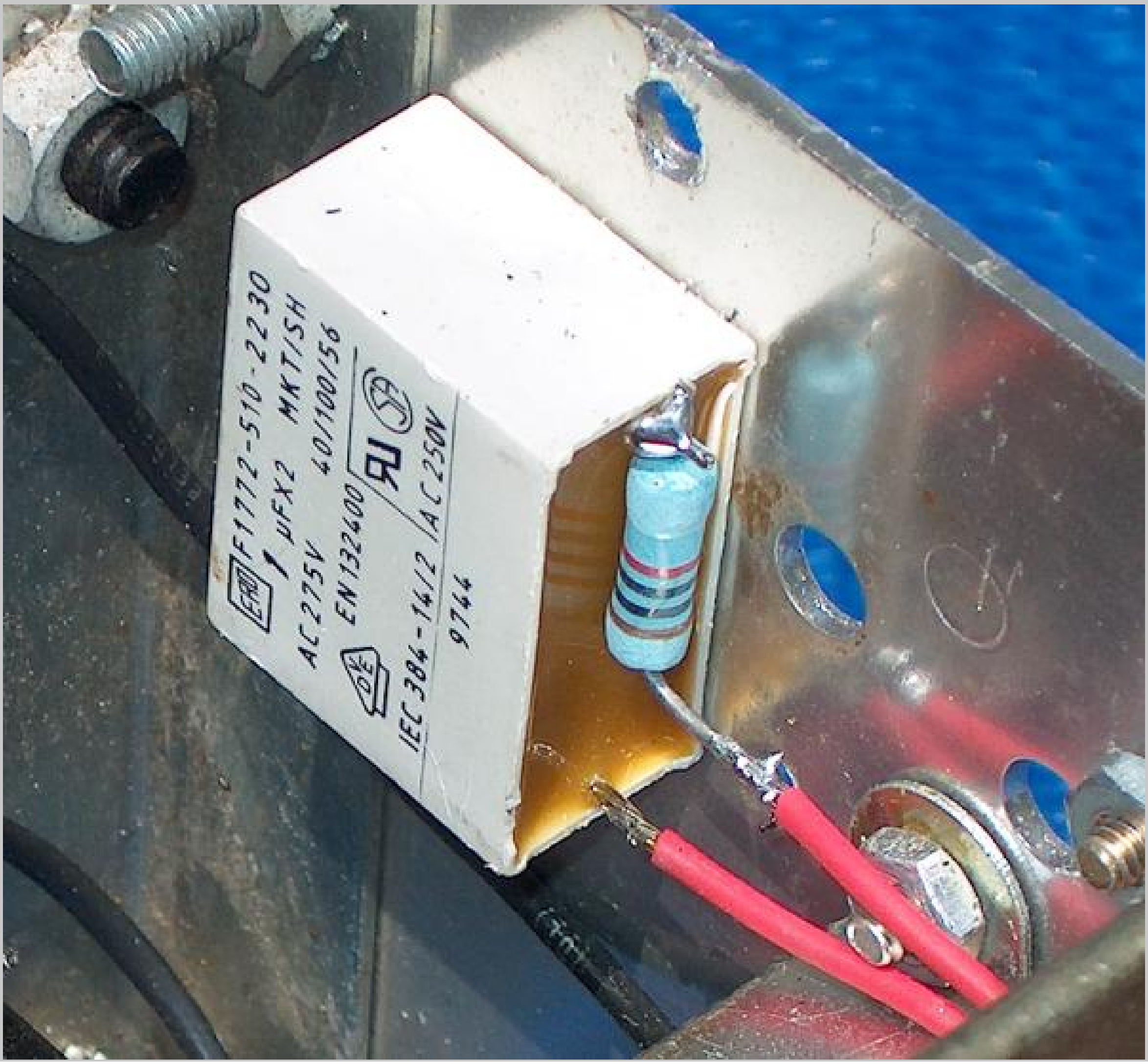
Placing two MOSFET's in parallel causes each one to carry half of the total load current. Whichever MOSFET happens to conduct slightly better than the other one (transistors are never exactly identical) will get a little hotter, which will increase it's resistance, and the resulting increase in voltage drop across the MOSFET will cause the other MOSFET in parallel with it to conduct more of the total current. This effect automatically forces the MOSFET's to share current evenly when they are operated in parallel.

Even better, paralleling MOSFETS results in something for nothing - the total power lost in heat is half of the loss when just one MOSFET is used. For example, assume that a single MOSFET drops 2 volts when carrying a current of 2 amperes. The loss is then 2v X 2a = 4 Watts. Splitting the current between two MOSFET's results in 1 ampere of current through each MOSFET, but since the voltage drop is proportional to the current, the voltage across the MOSFET's falls to 1 volt. Now the power loss for each MOSFET is 1v X 1a = 1 Watt times 2 transistors = 2 watts total loss. Not only have we decreased the total heat loss in the circuit by half, we have reduced the heat loss in each MOSFET to one-fourth of the original value.

At high power, this can mean the difference between comfortable operation and blown transistors. Using the aluminum heat spreader block allows sudden heat surges generated under overload conditions to be rapidly removed from the transistors and dissipated over a larger chassis area than would be possible if the transistors were bolted directly to the chassis without the use of the Aluminum block.

It is important that the MOSFET's are mounted so that their leads can be connected together with short leads. This is necessary for proper current sharing and to prevent VHF oscillations. The heavy copper wire from the MOSFET source leads to the chassis may be seen in this picture.

MOSFET's are good choices for power inverter use, because the I^R power loss and the resulting heat generated at full power operation are less than the losses in bipolar devices. The combination of the thin (1/8") aluminum chassis and the aluminum block provides sufficient heat sinking for the MOSFET's. The thermal mass of the heat spreader blocks and the surrounding chassis material allows overload operation up to 700 watts for several minutes. (The fuses blow out at that point.)



This is the RC snubber network that is placed across the winding of the oscillator transformer. It is used to clean up the waveform and helps produce a clean square wave from the oscillator. Note that all three capacitors used in this modification have been salvaged from used computer power supplies. The capacitor is attached to the chassis the lazy Ham's way - I Super Glued it there!!

A close up of the RC snubber that is placed across the primary of the output transformer. This network takes care of the energy stored in the leakage inductance in the transformer. The network is "tuned" by adjusting the R8 and C2 values for the minimum waveform "ringing" (transient oscillations") as seen on the drain of the MOSFET's. This adjustment needs to be balanced against the minimum crossover (switching) waveform spike as seen at no load. Allowing the switching spike to get too large can result in failure of the MOSFET's. Note that changing the value of C3 will require adjusting the values of the R8 and C2, seen here.

This is waveform correction capacitor C3. It must be rated for at least 250 volts AC. This capacitor was salvaged from a computer power supply.

If you've followed me this far, it's time to take a look at the schematic diagram and the specifications for some of the components. These are all PDF files.

Schematic diagram of the inverter

Data sheet for the 1N2805 Zener Diode

Data sheet for the 2SC2625 transistor

Data sheet for the HUF75645P MOSFET

Schematic Diagram Discussion:

The design of the oscillator circuit is the most critical in this inverter. In an attempt to make the design as simple as possible, some design features were omitted that may make purists cringe. However, tests to destruction (!) revealed that for the most part, what is shown here works just fine.

The oscillator is a simple cross-coupled saturated core design. The oscillator frequency is controlled by several factors, the DC supply voltage, the inductance of the transformer, the load across the transformer, and the base drive to the oscillator transistors.

The transformer was chosen based on the fact that most small transformers are designed to operate at the design voltage with the magnetic flux level in the core somewhat running somewhere below core saturation. Because most commercially available transformers use core material with similar magnetic characteristics, using a center tapped winding transformer with an end-to-end AC voltage rating roughly equal to the DC supply voltage will result in an oscillator running somewhere close to the transformer's design frequency. There are exceptions to this, of course, if the core material has greatly different magnetic characteristics.

The reason we need to apply 12 volts across one half of the 12 volt winding of the transformer is because the peak flux generated by a 12 volt AC sine wave is greater than the peak flux generated by a 12 volt DC square wave. Since the oscillator functions by virtue of core saturation, we have to allow enough time for the core to saturate with the 12 volts DC applied to the transformer winding. If we used the entire winding, the time required for the flux level to reach saturation would be greater than desired, and the result would be an oscillation at a frequency of less than 60 Hz. By using only half of the winding, the frequency is raised to about 90 Hz. This is then reduced to 60 Hz by reducing the DC supply voltage and adjusting the base drive of the oscillator transistors.

The transformer sees a reactive load due to the capacitance of the gates of the MOSFET's. This capacitance is across the transformer winding, and so will reduce the resonant frequency of the oscillator slightly.

The DC supply voltage is a critical component in frequency tolerance. The voltage is held to a very tight tolerance by using a 50 watt 7.5 volt Zener diode. The selection of the voltage to be used was set by the fact that the ends of the oscillator transformer winding are connected directly to the gates of the MOSFET's. Since the MOSFET's have a maximum allowable gate voltage of +/- 20 volts, I needed to ensure that the drive signal from the oscillator circuit would not exceed that value. When the oscillator is running, the MOSFET gate voltage will swing between +15 and 0 volts, causing the MOSFET to switch on and off. 15 volts is a reasonable value, and allows some safety margin. This sets the oscillator DC supply voltage at a maximum of +7.5 volts. The DC supply voltage is doubled because of the action of the oscillator transformer as the oscillator transistors switch on and off.

The selection of the oscillator transformer sets the transformer inductance, and since we have set the DC supply voltage with the Zener diode, and we have set the load on the transformer by choosing a particular MOSFET, the only remaining variable is the base drive to the oscillator transistors. That makes it easy to get the right

frequency - just trim the value of the crossover feedback base resistors, and the job is done! There is a small frequency change as the oscillator transistors warm up, but this is normally less than 0.1 Hz and settles down after about 5 minutes. Excessive frequency drift may indicate insufficient heat sinking of the oscillator transistors or excessive base drive.

Note that the worst possible failure mode is for the oscillator to fail to start. In that case, a steady +7.5 volts will be applied to the gates of the MOSFET's. Transformer T2 will then saturate, and allow excessive current to pass through the transformer primary winding and the MOSFET's. Something's will blow out, and hopefully it will be the fuse. More likely, it will be a blown out MOSFET, which then blows the fuse.

Fuse failure during normal operation is usually the result of overloading the inverter. In that case, the total DC current is shared by all four MOSFET's so the chances are that you'll have a blown fuse before you fry a MOSFET.

No current limiting resistors are used between the oscillator transformer and the gates of the MOSFET's. This causes more rapid turn on and turn off of the MOSFET's and also helps prevent cross-conduction between the MOSFET's during the switch time.

R6 and R7 are only used for ESD protection during construction, and are not required for proper operation. I normally solder ESD protection resistors across the gate and source leads of MOSFET's when I work with them, and usually just leave them in place after they are installed in the circuit.

Make the source leads nice and short between the transistors and chassis ground. Long leads can cause VHF oscillations. If this happens, place a small ferrite bead over the gate leads of the MOSFET's. You can usually find some suitable ferrite beads on the rectifier diodes in computer power supplies.

As always, Tune for Minimum Smoke!

73, Ralph W5JGV

[Home]

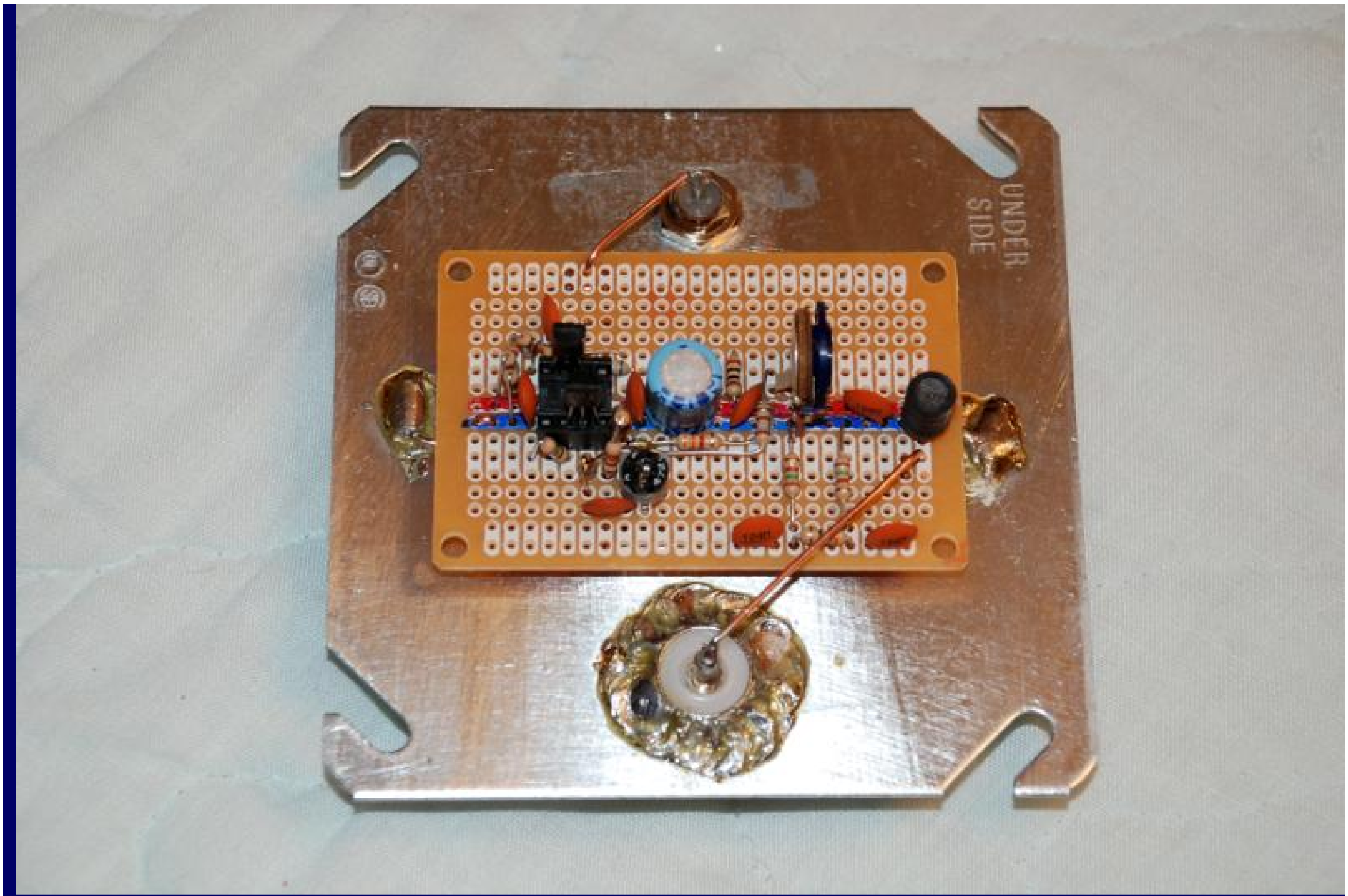
A Remotely Powered RF Preamplifier for the 600 Meter Band

Sept 17, 2007 - By W5JGV

When I needed an effective RF preamplifier for my Tree Antenna I wanted a low-noise unit, with lots of gain. It needed to be able to cover frequencies from a hundred KHz or so up to about 30 MHz. I also wanted to be able to power it over the coax cable connecting it to the receiver. I thought about doing a ground-up design for the amplifier, but, instead, I did what every good engineer does when confronted with a similar design problem - I swiped the design from someone else. After all, why re-invent the wheel?

A search of my computer files quickly located a nice looking amplifier designed by Philip Atchley, KO6BB. The original circuit is located HERE.

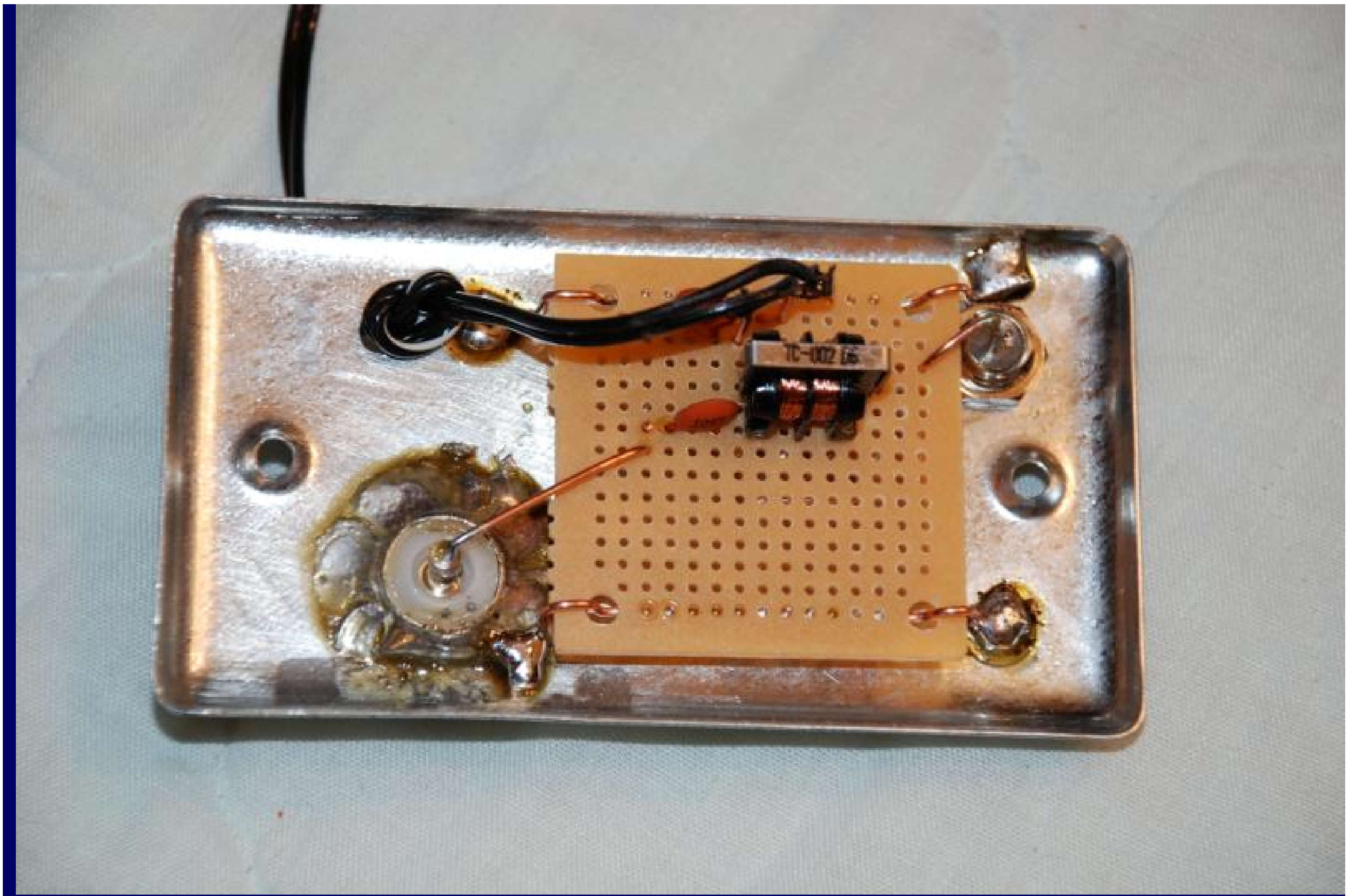
The finished amplifier is in the box on the right. The DC power injector is in the box on the left. For optimum results at HF, a 50 Ohm coaxial cable should be used to connect the two units. At LF and MF, just about any cable will work. I used some RG-6 coax cable for connecting the units to my tree antenna. The amplifier has ample gain, so feedline losses are not a problem. The RF amplifier and the power injector circuit boards are mounted on the reverse side of the cover plates of their respective enclosures.



The amplifier is built on a small perf-board obtained at Radio Shack. Parts are placed as closely as possible to match the schematic diagram. Some variation in placement is necessary to fit all the parts in place. I used an 8-pin DIP socket to hold the transistors. That will make it easier to replace them when Mr. Lightning visits the neighborhood.

A steel electrical junction box is used for the enclosure. It is very well shielded, and is sturdy and best of all, cheap!

For the connection back to the power injector, a UHF-type chassis connector was used. This connector was soldered to the metal plate. It was easier to solder the connector in place than to use nuts and bolts. For the antenna connection, I used an "F" chassis connector. This allows me to simply slip a bare #16 to #18 AWG wire into the connector.



The inside of the DC Power Injector is simplicity itself. I used a surplus "Wall-Wart" DC power adapter for the amplifier power. Not having a suitable power plug and jack readily available, I just drilled a hole in the metal plate and ran the power wire through the hole, tied the wires in a knot, and soldered things together.

Note the use of the small common mode RF choke used to keep the RF out of the DC power supply lines. Again, as in the amplifier box, a set of UHF and "F" chassis connectors were used. Here, the "F" connector takes the coax cable from the power injector to the amplifier. The UHF connector goes to the receiver. I did that on purpose, because I use a 100' length of RG-6 cable with "F" connectors on both ends to connect the tree antenna to the hamshack. The through connector in the tuning cabinet on the tree antenna has an "F" connector outside, and a UHF connector inside, hence, house-to-tuner is "F" to "F", and tuner-to-amplifier is UHF to UHF. All clear now? <G>

Here is the finished amplifier installed in the antenna tuning cabinet. As built, it delivers a solid 30 dB of gain, with a low noise figure, which is set by the J310 transistor. If you get excessive front-end noise, try another J310. they do not all have the same RF characteristics.

End Notes

- Download the original amplifier design article by KO6BB HERE.

Philip has a very good write-up on the functioning of the amplifier, and, with the exception of the DC power injector and the different bipolar transistor. his adjustment procedure works very well with my version.

Both versions include a 6 dB resistive pad in the output to ensure stability. The J310 front-end RF amplifier always runs "wide-open" for best noise figure. Variable overall RF gain is provided, so the output of the amplifier may be set as needed to compensate for feedline losses and your particular receiver setup.

In my station, I need to feed several receivers from the same antenna. I have found by testing, that some ordinary cable TV RF splitters will work quite nicely all the way down below 500 KHz. I have one of these attached to the output of this amplifier to feed two receivers at once. This amplifier has sufficient output to be able to drive as many as eight receivers simultaneously with an 8-port splitter.

- Download the schematic of my version of the amplifier HERE.

- Download the schematic of the DC Power Injector HERE.

- Download the specs on the J310 transistor HERE.

- Download the specs on the 2N5089 transistor HERE.

73,

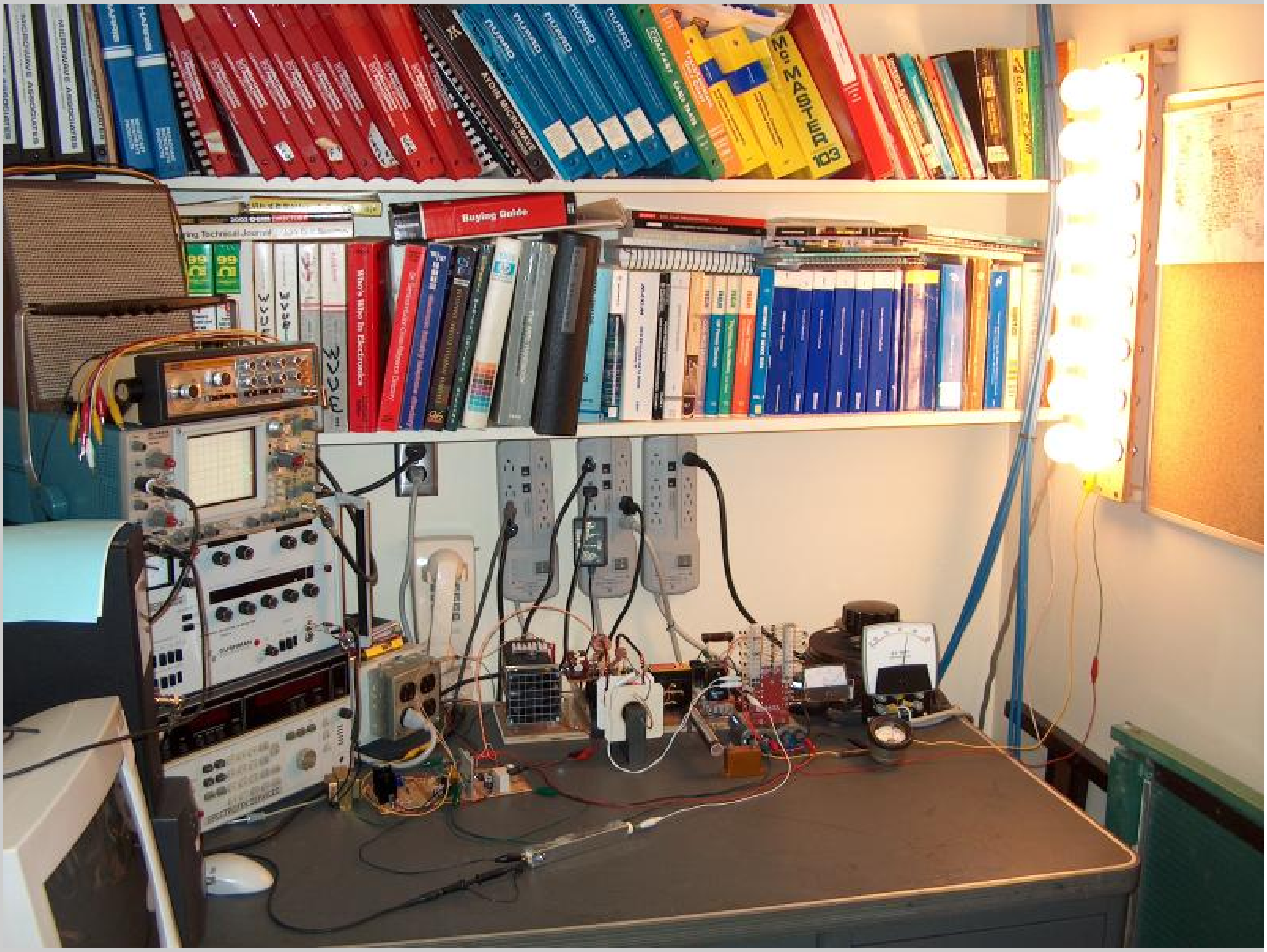
Ralph - W5JGV - WD2XSH/7

[BACK]

A KW Switch Mode Regulated High Voltage Power Supply

By W5JGV

Last Updated September June 8, 2005



Bench Testing of the Switching Power Supply

SAFETY WARNING!!

This unit handles voltages and currents that can be INSTANTLY LETHAL upon contact. Both the input and output ends of the unit are dangerous, as they both contain high voltages and are capable of high currents.

IF YOU DO NOT HAVE EXPERIENCE IN WORKING WITH HIGH VOLTAGES, THEN DO NOT ATTEMPT TO CONSTRUCT THIS POWER SUPPLY WITHOUT THE GUIDANCE OF A PROPERLY QUALIFIED INSTRUCTOR.

DEATH IS PERMANENT

PLEASE BE CAREFUL!!

The data sheets listed below are all in Adobe PDF format.

I suggest that you download these files for reference while reading the circuit description.

Click HERE for the schematic diagram of the 120 Volt unit.

Click HERE for the parts list for the 120 Volt unit.

Click HERE for the schematic diagram of the 240 Volt unit.

Click HERE for the parts list for the 240 Volt unit.

Click HERE for the data sheet on the TL494 switching controller IC.

Click HERE for the data sheet on the TL594 Switching controller IC.

***Note:* the ON Semiconductor version of the TL594 is a higher powered version of the more common TL494 and is a better choice for this circuit because it will provides higher IGBT drive capability. It also has a low voltage lockout circuit, which is not required for this power supply. The output transistors in the TL594 are rated at 500 ma, whereas the TL494 is rated at only 200 ma. However, the TL594 that is manufactured by Texas Instruments has the same current ratings as the standard TL494, and therefore has no particular advantage over the TL494. If you do use a TL594 in place of the TL494, it may be used with no circuit changes required.**

Click HERE for the data sheet for the HGTG27N120BN power transistor.

Click HERE for the data sheet on the UF4007 diode.

Click HERE for the data sheet on the Ferroxcube "U" transformer core.

Click HERE for the data sheet on the Ferroxcube "I" transformer core.

The following files are useful as reference material if you want to design your own switching power supply:

Click HERE for "Topologies for Switched Mode Power Supplies"

Click HERE for "ON Semiconductor SMPS Power Supply Design Manual"

Click HERE for the "Fuji IGBT Application Manual REH984"

Click HERE for "Design of Magnetic Components"

Click HERE for "Inverter Transformer Design and Core Selection"

Click HERE for "Reactive Elements in Switched Power Conversion"

Click HERE for "Wakefield Heatsink Thermal Tutorial"

The following files were added on June 8, 2005

Click HERE for "Choose Wisely" IGBT or MOSFET selector"

Click HERE for "IGBT Basics" by Motorola

Click HERE for "IGBT Basics by Fairchild

Click HERE for "Introduction to IGBT Operation"

Click HERE for "IGBT Gate Drive for Maximum Efficiency"

Click HERE for "Stranded Wire as a Substitute for Litz Wire in Transformers"

The following files are in MPG format. They show the power supply 3 second startup cycle.

Click HERE for a wide view video of the startup showing the lamp load

Click HERE for a video of the voltage and current meters during startup

Click HERE for a video of the PWM waveform during startup

OVERVIEW

This intent of this article is to provide useful information so that a copy of this power supply, or one similar is design may be built by an experienced experimenter or Amateur Radio Operator using the components and techniques specified here. The concepts and techniques described here may also be used to assist the experimenter in designing his or her own switching power supply. With few exceptions, most of the components used in this circuit may be substituted with other components, depending on the depth of the experimenters junk box.

The design of switching supplies is a bit more involved than traditional "big iron" transformer power supplies. When taken step-by-step, however, it is quite possible for an amateur to design and build a working high power switching power supply. This article describes a high power, high voltage switch mode power supply designed to operate a KW level RF power amplifier.

This power supply was designed to replace the original power supply in a Heath Warrior power amplifier which uses 4 - 811A tubes. With some minor modifications, this amplifier may be pushed to the maximum tube rating in SSB service. This requires a plate voltage of 1500 volts and a per tube plate current of 175 milliamperes.

SPECIFICATIONS:

- Mains Voltage - 120 or 240 volts, 50 - 60 Hz, single phase.
- Output Voltage - 1100 - 1500 Volts DC, adjustable, and regulated against load or mains voltage changes.
- Output Current - 50 - 750 mA DC.
- Output Watts - 1125 maximum.
- Duty Cycle - Continuous Duty.
- Soft Start Ramp-Up to full output voltage approximately 3 seconds after power on command.

- Output Short Circuit Protection - Adjustable, normally set to 1 Ampere; shutdown within 10 microseconds of fault event.
- Switching Transistor Overcurrent Protection - Adjustable, 5 - 15 Amperes; shutdown within 10 microseconds of fault event.
- Protected Manual Overload Reset circuit prevents accidental destruction of switching transistors due to operator error.
- Output Voltage Regulation measured at 1500 volts output with a load change from 25% to 100% is 0.13%.
- Output Transient Voltage drop measured at 1500 volts output with a load change from 25% to 100% is 2 volts.
- Transient Recovery Time with a load change from 25% to 100% is approximately 200 microseconds.
- Residual noise measured above 120 Hz is less than 250 millivolts at any load between 25% to 100%. (0.017% noise.)
- Residual 60 and 120 Hz ripple measured with a constant load anywhere between 25% to 100% load is less than 2 volts peak-to-peak.

SUMMARY OF OPERATION

The AC mains voltage is rectified and filtered into DC. The DC is then chopped up by a pair of power transistors into a string of alternating positive and negative 130 volt pulses at a frequency of 27 kHz. These pulses are sent to to a step-up transformer and transformed into a 1,600 volt AC square wave. The 1,600 volts is rectified and filtered into DC to power the load. A sample of the 1,600 volt output is used to control a pulse width modulator (PWM) which adjusts the width of the pulses that are sent to the step-up transformer. By adjusting the width of these pulses, the PWM controls the amount of power available to the load. The PWM adjusts the pulse width so that the filtered DC output voltage remains constant as the load or mains voltage changes. Suitable protection is included so that the supply will not suffer a catastrophic failure in the event of an overload or accidental short circuit across the output terminals.

DETAILED DESCRIPTION:

Please refer to the schematic diagram of the power supply for the following discussion. You may use either the 120 volt or the 240 volt version, as the only difference is in the AC mains area of the schematic diagrams.

AC INPUT AND RECTIFIERS:

Primary mains power enters the power supply through a line filter FL1, which is designed to prevent RF noise which may be generated by the power supply from getting into the power lines and causing interference. I used a filter salvaged from a large computer power supply. The mains voltage is then rectified and used to charge a pair of primary DC power filter capacitor banks.

Each of the filter banks, C3 and C4 are made from 6 - 680 uF electrolytic capacitors connected in parallel for a total capacity of 4080 uF at 200 VDC. Both filter banks are identical. Because of the high value of ripple current passing though these capacitors, these filter banks use capacitors which are designed for computer switching power supplies. I used capacitors salvaged from some old 250 watt computer power supplies. One filter bank will be charged to plus 130 volts DC and the other filter bank will be charged to minus 130 volts DC by the rectifier.

Note that the 120 volt version uses dual half-wave rectifiers D1 and D2 which charge each capacitor bank on opposite polarities of the AC mains wave. The 240 volt version uses diodes D1, D2, D55 and D56 which are connected as a full-wave bridge rectifier. In the 240 volt version, the mains voltage charges both capacitor banks at the same time, but with opposite polarities. This means that the 240 volt version will have double the mains ripple frequency, and a lower ripple amplitude than will the 120 volt version. Fuse F1 in the 120 volt unit and F1 and F2 in the 240 volt unit protect the unit from mains overloads.

A pair of 4 watt, 130 volt light bulbs Y1 and Y2 are connected across each capacitor bank, These lamps serve to provide a visual indication of the presence of rectified mains voltage and also act as bleeder resistors for the primary filter capacitors and to discharge the primary filters when the mains power is removed.

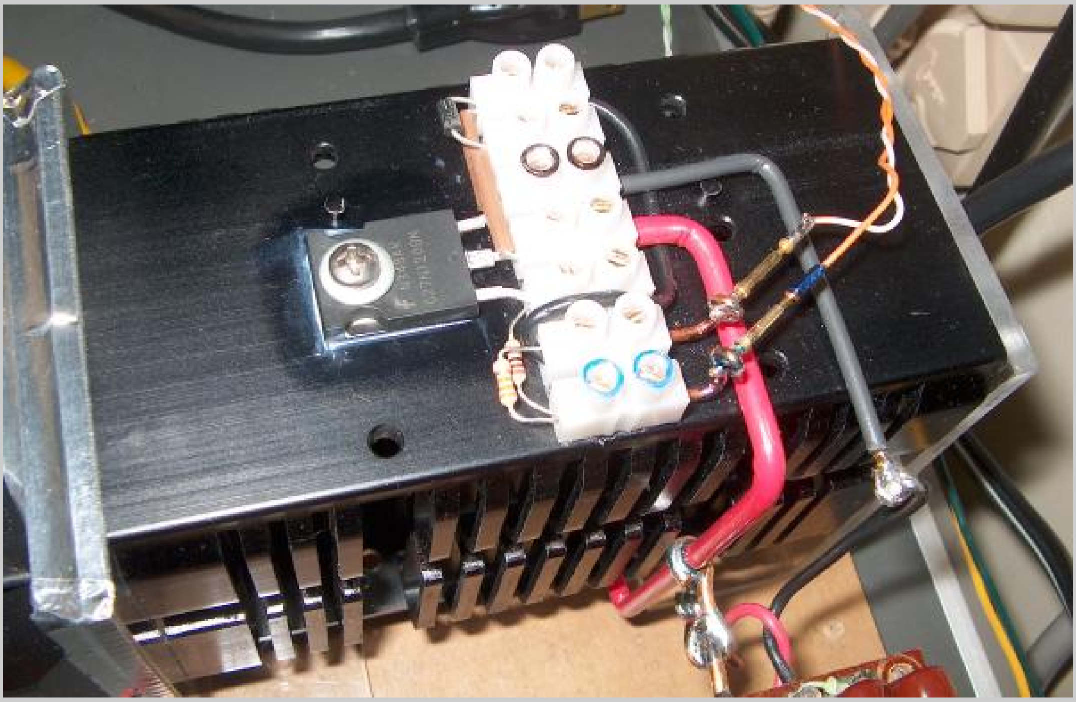
Inrush mains current surge protection is supplied by resistor R6 in the 120 volt unit, and by resistors R6 and R34 in the 240 volt unit. The surge resistors are bypassed by the normally open contacts of relay K1 after the pre-charge time delay

supplied by time delay relay K2. K2 starts its timing cycle when AC mains power is applied by closing switch S1 to begin charging the main DC filter capacitor banks.

HALF-BRIDGE SWITCHER:

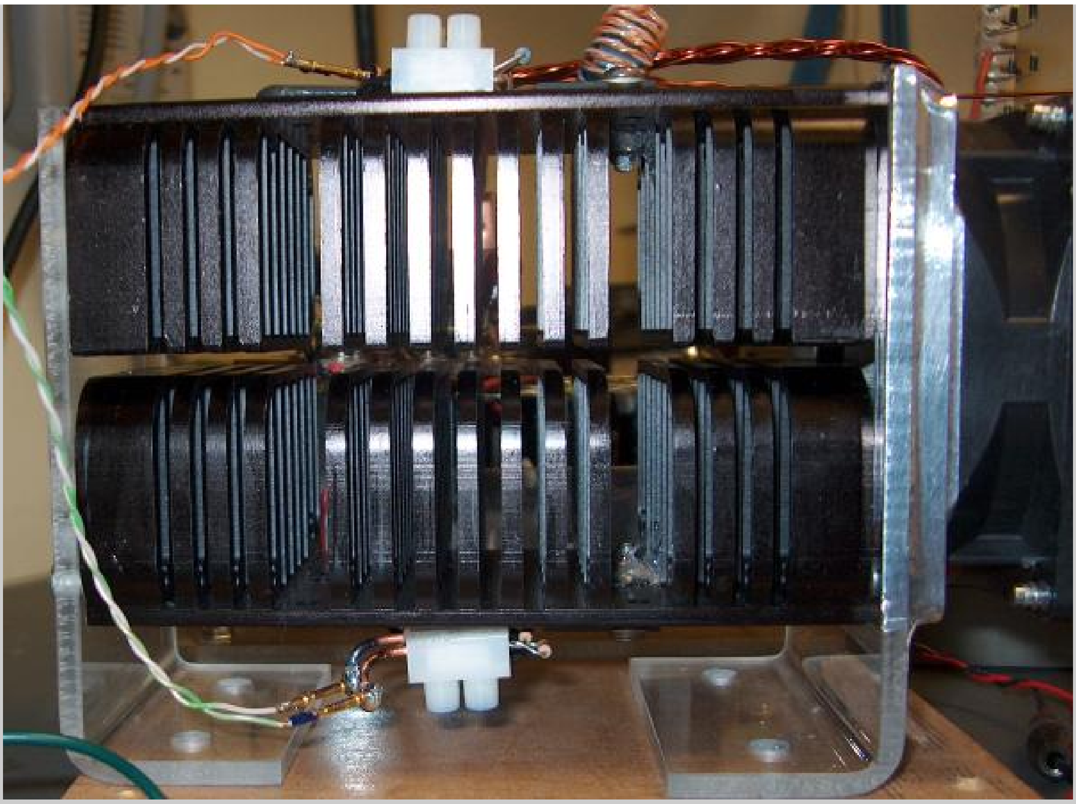
The power supply uses a half-bridge power switching circuit. In this design, one side of the primary winding of switching transformer T2 is connected to the primary DC power common return point, (the junction of C3 and C4) and the other end of the primary winding is connected to the emitter-collector junction of the two switching transistors. The transistors are connected and driven such that one transistor will switch +130 volts to the primary winding of the transformer, and the other transistor will switch -130 volts to the primary winding of the transformer.

NOTE: *In the 120 volt version, this common point is connected directly to one side of the mains supply. In the 240 volt version, the common point will be connected to the mains common return line, which normally will be at earth potential, but don't count on that as always being true. Safety first - check everything and stay alive!*



One of the two switching transistors mounted on its heat sink.

The transistor shown here is Q2. Each transistor is mounted on a separate heat sink. No insulating spacer is used between the transistors and the heat sinks, as it is necessary to ensure that the transistors remain as cool as possible to prevent the increased losses which occur at elevated temperatures. A terminal strip is placed by each of the switching transistors. The terminal strip is used to hold the spike suppressor diodes D3 and D4. The heavy red wire connects the collector of Q2 to the emitter of Q1.

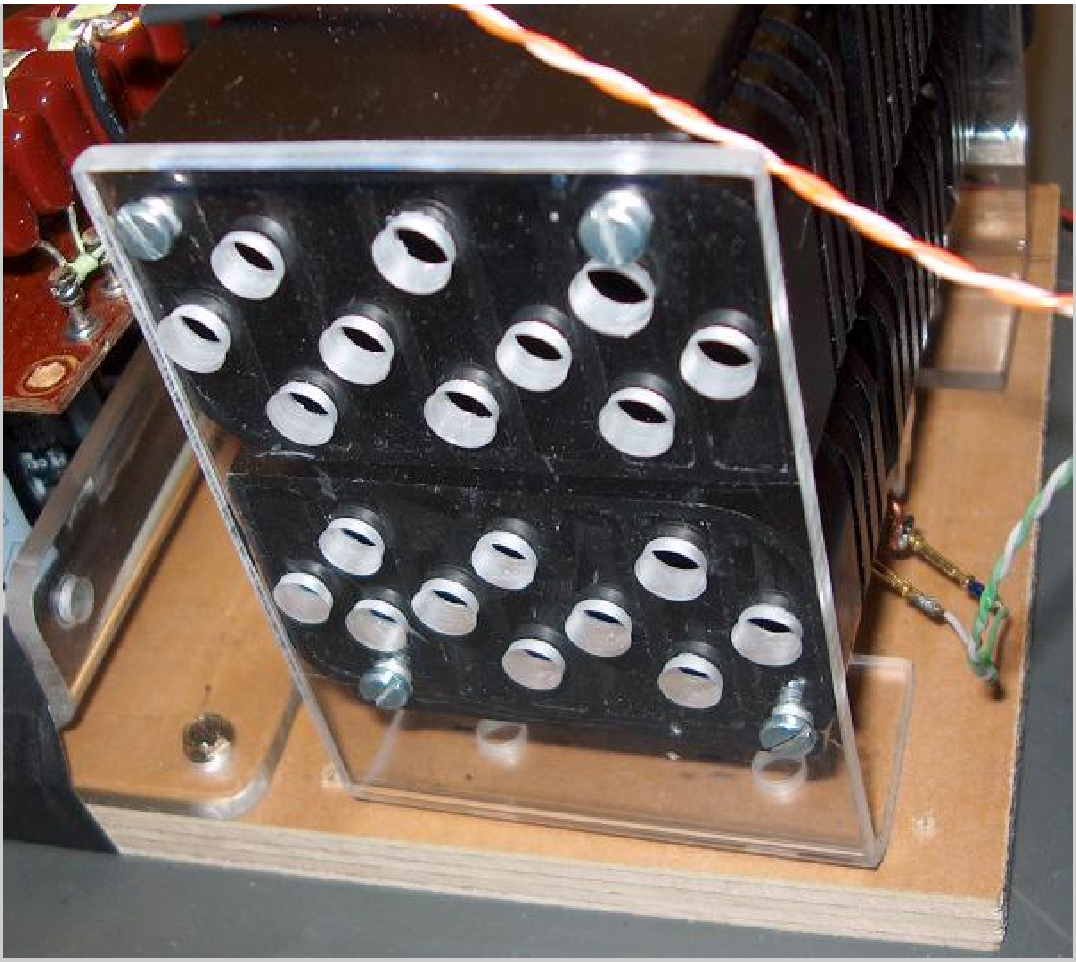


This is a side view of the heat sinks as they are assembled in the power supply.

Since there is 130 volts difference in potential between the two heat sinks, they are mounted on a pair of insulating angle brackets which are made from 1/4" thick clear plastic sheet. The heat sinks themselves are salvaged from some used Pentium II processors. The heat sinks are separated slightly so that there is no electrical contact between them.

A small cooling fan, which was salvaged from an old computer supply, is attached to the plastic bracket which holds one end of the heat sink assembly. The plastic bracket has an opening cut into it so that the cooling air from the fan will pass lengthways through the heat sink. Heated air flows outwards horizontally from the heat sinks.

Note the aluminum foil tape which is used to hold the fan against the plastic bracket. If you mount the fan in this manner, make sure that the aluminum foil does not short circuit the two heat sinks!! Since these heat sinks are at 130 volts above earth potential, the foil should not contact either heat sink. For safety, be sure to protect the heat sinks from accidental contact by the operator or bystanders.



This bracket is attached to the end of the heat sink assembly opposite the cooling fan.

Notice the holes that have been drilled through the plastic bracket. These holes are there to allow some of the heated air to escape from the end of the heat sink, otherwise there would be a dead air pocket at this end of the heat sink which would have reduced the cooling efficiency of the heat sinks.

Home brew fan guard.

The edges of the blades on the cooling fan are sharp - trust me on that! I fashioned a fan guard from a small section of "hardware cloth" which has 1/2" spacing between the wires. By chance, it turns out to be a perfect fit between the mounting screws, which, when screwed into the mounting holes, holds the hardware cloth firmly in place.

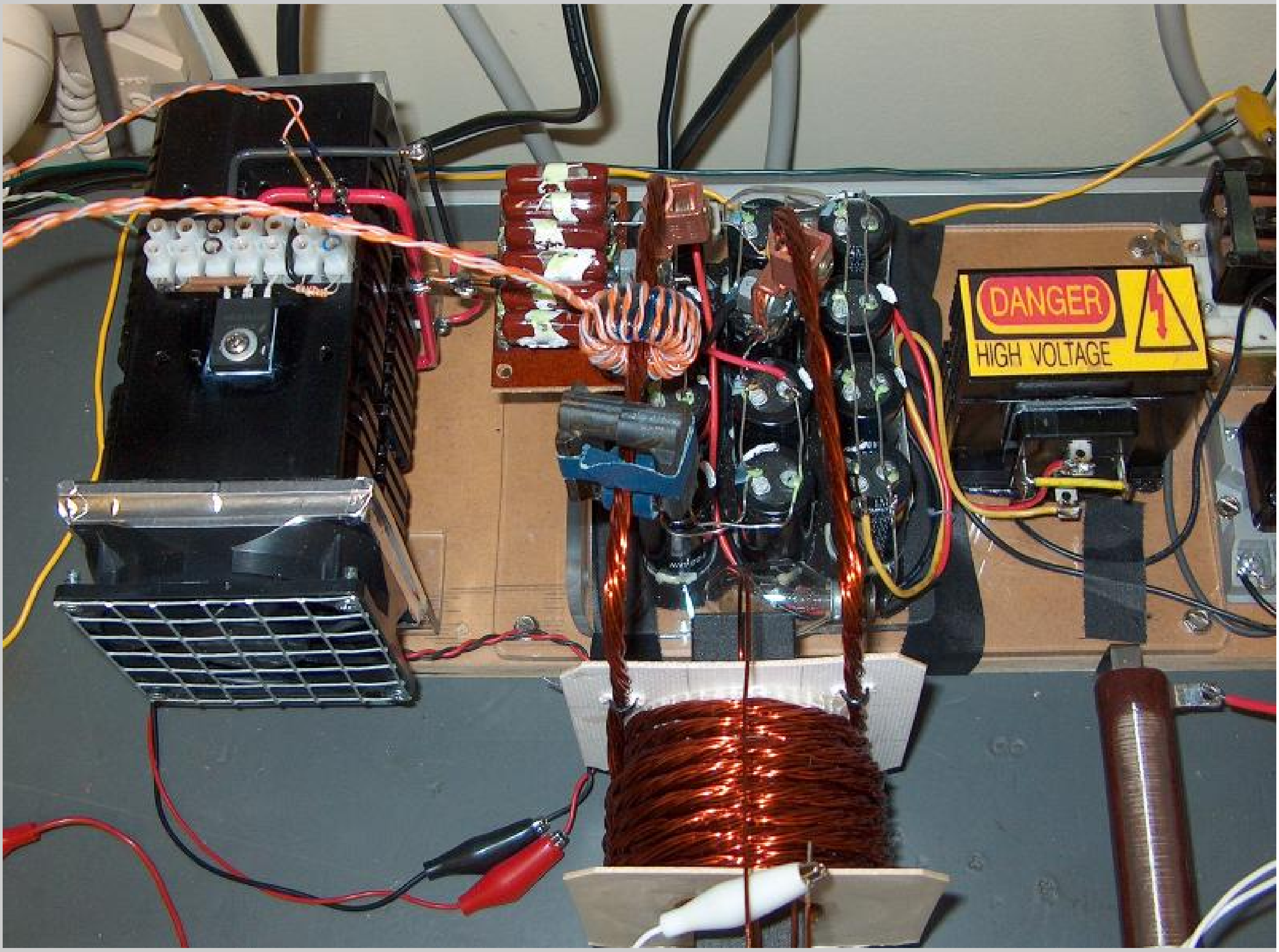
POWER SWITCHING TRANSISTORS:

Now that we have the primary + and - 130 volt DC power available, we must transform it to 1,500 volts. To do so, we use a pair of high voltage, high current IGBT's (Insulated Gate Bipolar Transistors) to create a 130 volt AC waveform by alternately switching the plus and minus 130 volts DC from the primary filter capacitors into a ferrite core step-up transformer. This transformer steps up the 130 volt AC signal to approximately 1,600 volts AC on the secondary winding of the transformer.

The transistors Q1 and Q2 that are used for this task are Fairchild type HGTG27N120BN IGBT devices, which are rated at 1,200 volts and 72 amperes. After reading the fine print in the data sheets, we see that these are the maximum ratings at for operation at DC, but when we operate them at higher frequencies, the allowable current drops considerably. In the unit described here, the transistors are operating at 27 KHz, which reduces the allowable current to about 15 amperes. That is more than sufficient for our needs. The 1,200 volt rating applies regardless of the operating frequency. The 1,200 volt rating also gives the supply excellent protection against transistor failure due to voltage spikes. Other IGBT or MOSFET

transistors could be substituted for the transistors used here, as long as they have a voltage rating of at least 600 volts and a current rating of 12 amperes or more at an operating frequency of 27 KHz.

The switching transistors are protected against reverse voltage spikes by the use of fast switching UF4007 diodes D3 and D4 which are placed across the emitter and collector of transistors Q1 and Q2.



The "Heart of The Switcher"

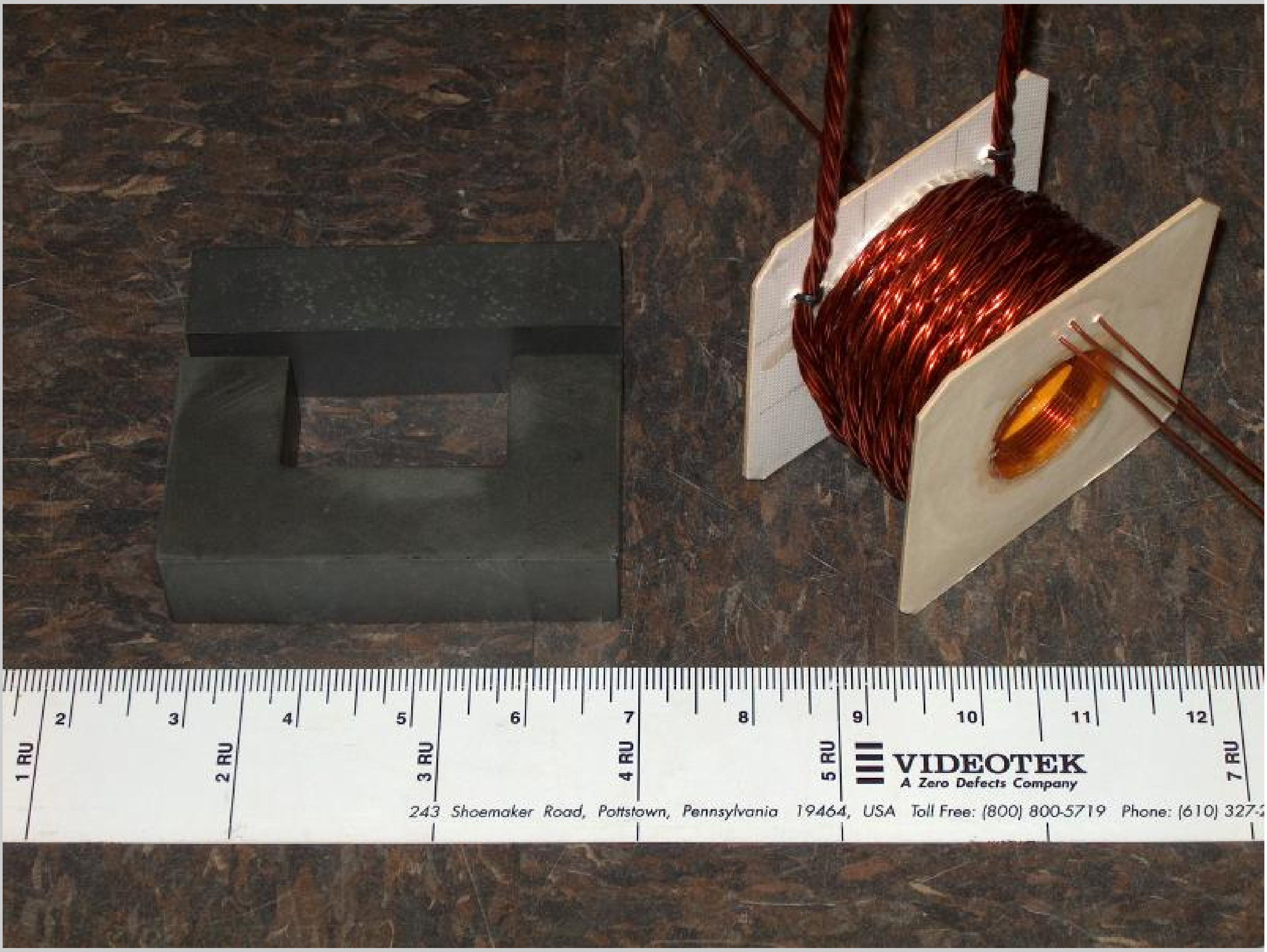
This shows one of the two IGBT power switching transistors which are mounted on their individual heat sinks, (The other switching transistor is mounted underneath the heat sink assembly,) the filter capacitor banks, the DC blocking capacitor, the switching transformer, the mains rectifier on its heat sink, and the overcurrent sample transformer. The small square black ferrite core transformer seen in front of the overcurrent sample transformer is used to take a sample of the transformer current and send it to an oscilloscope so I can monitor it.

SWITCHING STEP-UP TRANSFORMER:

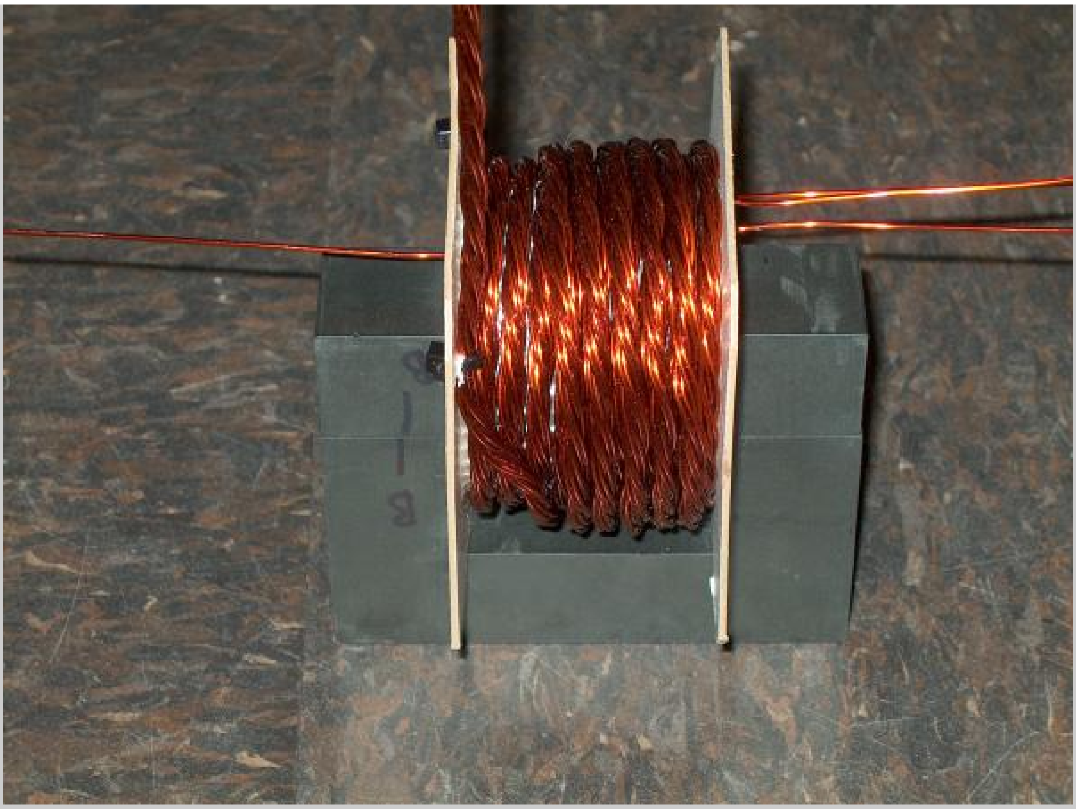
Transformer T2 is used to step up the 130 volt AC signal generated by transistors Q1 and Q2 to about 1,600 volts AC. Because of the 27 KHz switching frequency used in this system, a laminated iron core would exhibit excessive hysteresis losses. A ferrite core is used instead. Because a power level in excess of 1KW was required, a fairly large core was used. It would have been possible to use a smaller size core, since the one used here is capable of power levels in excess of 4KW, however using this large core allows the use of a relatively small number of turns of wire on the transformer, thereby reducing copper losses. In addition, the larger core has a greater window area, and allows much more leeway in placing the windings with plenty of space for cooling and insulation.

The operating frequency of 27 KHz was chosen for purely practical reasons. The higher the operating frequency, the smaller and lighter transformers are for a given power level. However, semiconductor losses tend to increase as the operating frequency is raised, and obtaining usable power transistors becomes more difficult and expensive. The power transistors used in this design were available at reasonable cost on the surplus market, and, if purchased new, cost less than USD $13.00 each. Since my first experiments were done using ferrite cores from LOPT's which operate at 15.75 KHz ,and with transformers salvaged from computer power supplies which operate between 40 and 100 KHz, it seemed that a frequency somewhere between 20 to 30 KHz would probably be suitable for use in this project.

The transformer core is assembled from two stock items from Ferroxcube. The part first is a "U" section, P/N U100/57/25-3C90, with a cross-sectional area of 6.45 cm^2. The second part of the core is an "I"-bar section, P/N I100/57/25-3C90, with the same cross sectional area. If additional core "window" area in needed to make room for more winding space, a second "U" section core may be substituted for the "I"-bar section with no loss in performance.



The picture shows the size of the core sections and the completed transformer coil.



The core sections as they are fitted to the coil.

SWITCHING TRANSFORMER CONSTRUCTION DETAILS:

The windings were wound on a coil form which was then slipped over the "I"-bar and then the "U" section was simply placed against the sides of the "I"-bar to complete the magnetic circuit. The core sections are held together with several wraps of glass reinforced tape.

The coil form for the transformer was constructed by obtaining a length of thin walled plastic tube which would just slide over the "I"-bar core section. I used a yellow plastic pill bottle with the ends trimmed off. The tube was cut to length so that it just fit between the ends of the "U" core section. Two square pieces of artists art matte board were then cut to fit inside the window area available when the core sections were assembled. Using a sharp knife, a snug-fitting round hole was then cut in the center of each piece of matte board. The matte board end plates were then fitted to the ends of the tube by attaching them in place with cyanoacrylate adhesive

Next, the end plates were given three coats of liquid plastic cement to prevent then from absorbing moisture from the air. I used clear PVC pipe cement. I allowed each coat to dry for several hours before applying the next coat of cement.

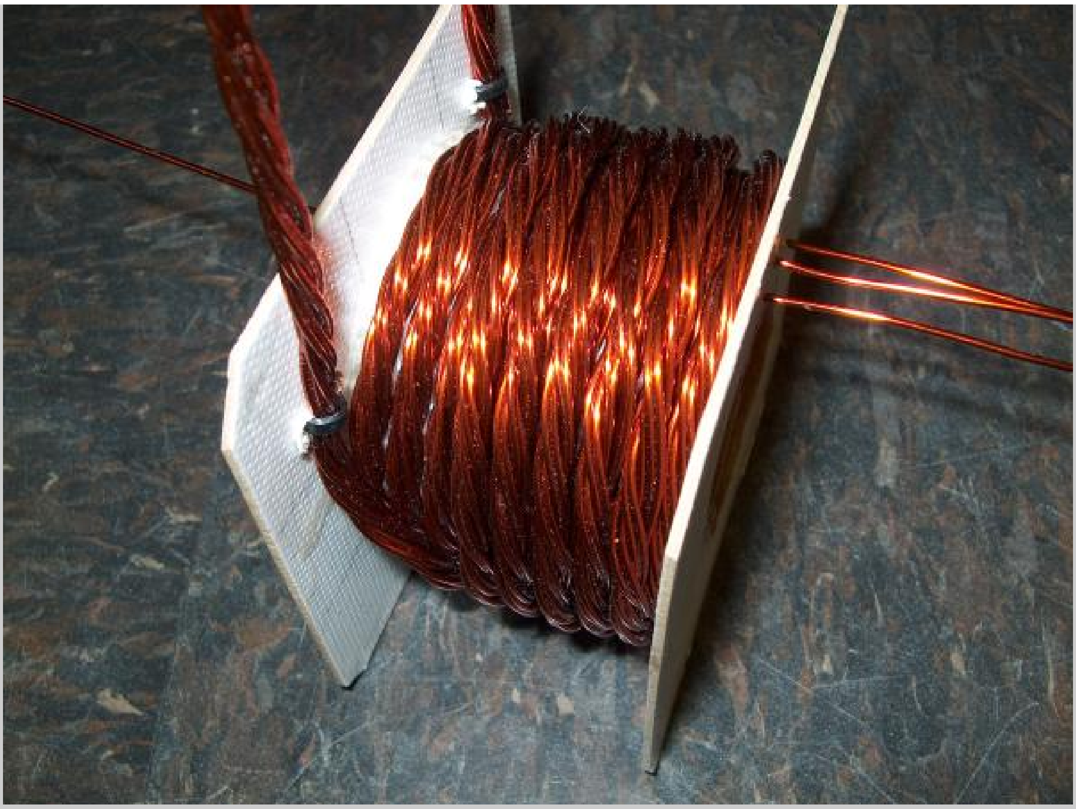
After allowing the coil form to dry, the secondary winding was wound on the form. It consists of 205 turns of # 18 AWG wire. The wire is larger than actually required (21 gauge would be adequate) even after factoring in skin effect and current crowding at 27 KHz, but I had a lot of the # 18 gauge wire available, and since there was plenty of room on the coil form for it, it was used.

The secondary winding has an inductance of about 436 mHy with the ferrite core sections in place, and has a self-resonant frequency of about 35 kHz.

The finished Switching Transformer Windings.

You can see the primary winding on the outside of the coil, and visible through the yellow plastic pill bottle tube in the center of the coil form is the first layer of the high voltage secondary. Note that there are extra secondary wires shown here. Since this was the first unit built, I added an auxiliary secondary winding to allow me to be able to adjust the output voltage for testing.

The primary winding has an inductance of about 1.6 mHy with the ferrite core sections in place.



Another view of the completed coil.

It is necessary to minimize the winding self-capacity to keep the winding self-resonant frequency as high as possible. The self-resonant frequency must be higher than the switching frequency, or the transformer will not perform properly. To do this I applied two layers of fiberglass tape over each winding layer as I finished the layer.

NOTE: To measure the resonant frequency of the transformer, insert the core sections into the coil and fasten them together with tape. Make sure the primary winding is open circuited. Using an audio oscillator that will go up to about 70 KHz, feed a sine wave through a 22,000 Ohm resistor to the secondary winding. Monitor the signal level across the secondary winding with an oscilloscope and a 10X probe. Adjust the frequency of the audio oscillator until you find the lowest frequency at which the sample signal is greatest. The frequency at which this resonant rise occurs is the resonant frequency of the transformer. It must be above 27 KHz for proper operation of the power supply.

I then continued winding the next layer of the secondary by carefully folding the wire back across the previously finished winding layer so that the next layer started from the same side of the form where the previous winding began. This required extra insulation between the folded over wire and the windings to prevent insulation failure. I did this by applying an additional strip of insulating tape crosswise to the just-completed winding layer. This was placed directly under the folded across wire. Two thickness of insulating tape were then placed on top of the folded across wire and the next layer was carefully begun.

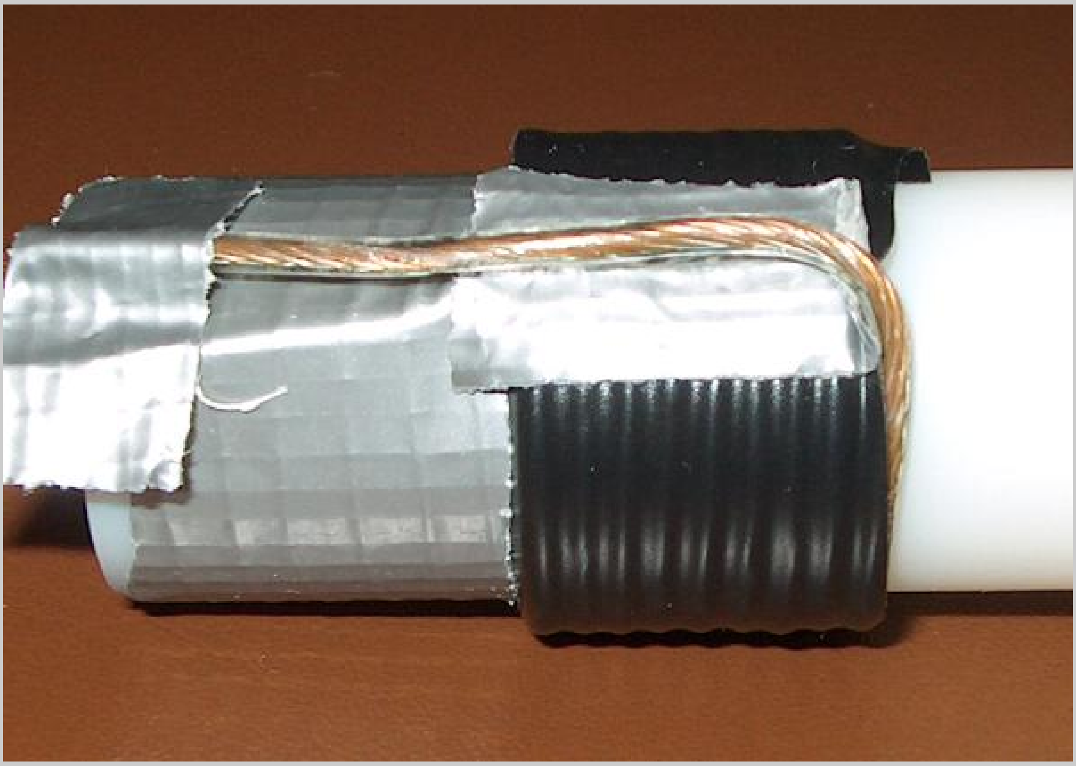
Note that it is vitally important to prevent a winding turn at the outer ends of the form from being "pulled under" and dropping down into the completed winding below the winding layer you are working on. If this happens, it is a sure invitation to an arc-over between layers and instant failure.

After completing the desired number of turns, the finished secondary winding was wrapped with several layers of insulating tape.

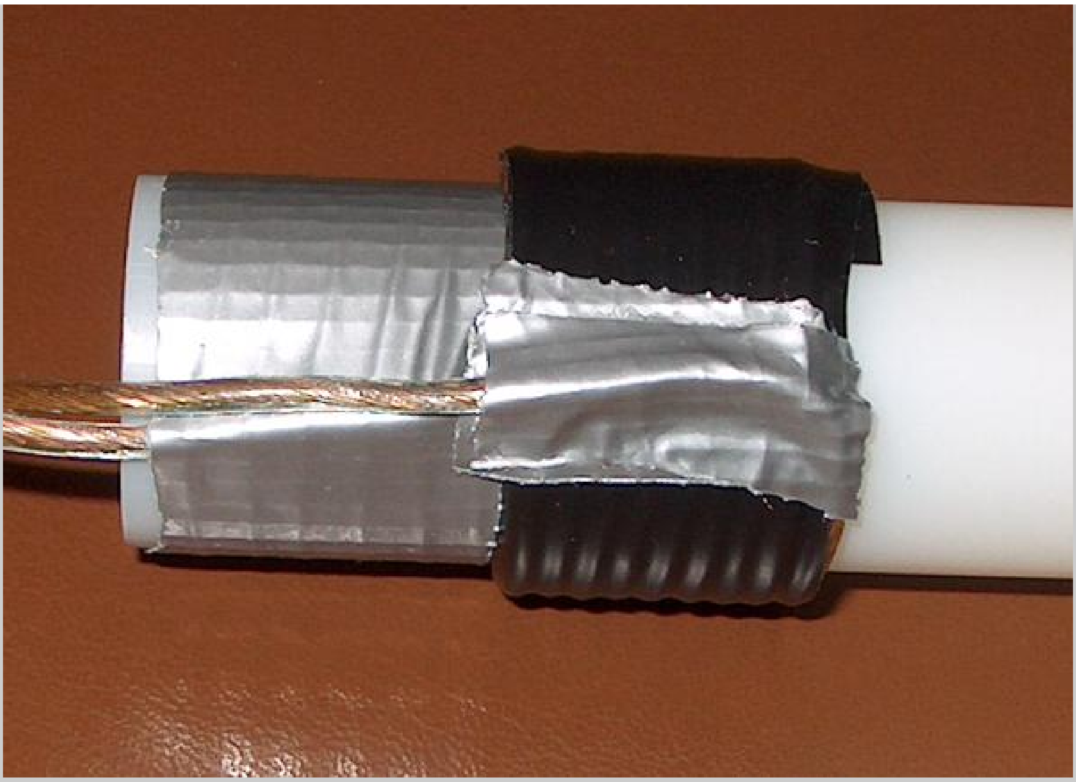
Because this text description of the winding process may not be easily understandable, I have illustrated the process with the following pictures and text. The illustrative winding shown in the pictures is not the actual transformer winding, but is used specifically to show the method of winding.

This illustrates the method of winding the secondary for minimum inter-layer capacity.

First, wind a layer on the coil form in the usual manner, with the layer close wound. In this example, the winding starts at the left side of the form and finishes at the right of the form. After finishing the winding layer, cover the winding with insulating tape. Note that for this example, I have used aluminized Duct Tape and plastic electrical tape, neither of which is actually suitable for the actual transformer. Use a Fiberglass tape instead. It will withstand heat and mechanical stress much better than plastic tape, and will not conduct electricity as Duct Tape will do at high voltages.



After insulating the first winding layer, place an extra strip or two of insulating tape across the finished winding layer and then fold the free end of the wire back across the winding layer directly across the tape strip.



Place a layer or two of insulating tape over the top of the folded-across wire. Because the folded-across wire will be subject to extra pressure from the winding layers wound on top of it, it is necessary to make sure that there is no chance that the folded-across wire will cut through the insulating tape and contact any of the turns in the winding layer. Depending on the thickness of insulating tape you use, you may need to use several thicknesses of tape over and under the folded-across wire.

Continue winding the next layer in the same direction as the preceding layer. Notice that by using the folded-across wire technique, the starting turn of every layer will be on the same side of the coil form. Using this winding technique, complete all of the winding layers needed for your transformer. Be sure to insulate every layer with insulating tape.

The primary winding is added next. Depending on your AC mains voltage, either 14 or 15 turns will work fine. Please note that with either 120 or 240 volt mains, filter capacitor banks C3 and C4 will be charged to about 130 volts, so the same number of primary turns are used on transformer T2. Use 14 turns on the primary if your mains voltage is on the low side, and 15 turns of it is normal or high. The voltage regulator circuit can easily compensate for high line voltage by simply decreasing the switching pulse width, but after the pulse width reaches the maximum, the output voltage of the supply will begin to droop if the mains voltage dips or is slightly low to begin with.

#8 or #10 AWG Litz wire would be ideal for the primary winding, but simply using multiple parallel strands of thin wire will be quite adequate. 8 parallel strands of # 18 AWG wire works well. I twisted the parallel wires into a pseudo-Litz arrangement, but I am not sure if the results are any better than simply winding the wires in parallel. In a pinch, ordinary THHN plastic covered solid # 10 AWG wire also works with slightly greater losses. Since the primary is on the outside, it's easy to make changes to it. A picture of my home brew Litz wire is shown below.

Home brew Litz Wire

The Litz wire was fashioned by taking two parallel strands of #18 AWG wire about 115 feet long and twisting them together in a clockwise direction with an electric drill until the twisted wires had about two turns per inch. The twisted wire was then cut into four equal length and laid side by side. Using the electric drill, the wires pairs were all twisted together into one wire bundle, but this time the twist was done in a counterclockwise direction. Twisting was stopped when the finished wire bundle had a twist of about one turn per inch.

The finished Litz wire was then wound over the completed secondary winding and attached to the coil form sides using plastic tie-wraps threaded through small holes punched in the sides of the coil forms.

Do not wrap the primary winding too tightly against the secondary - you do not want to crush the secondary winding. Do not use insulating tape over the outside of the finished primary winding. The winding will get fairly warm during operation, and it needs free air circulation to cool it properly.

Be sure to carefully clean and tin each strand of wire with solder. Make sure all the strands at each end of the twisted wire are completely soldered together so that each strand will carry an equal share of the primary current.

Before the final assembly of the transformer, make sure that the mating surfaces of the core sections are parallel, smooth and clean. When placing them together, ensure that the minimum air gap is obtained. You should not be able to see light between the core sections when they are placed against each other.

PRIMARY SNUBBER NETWORK:

All transformers have some leakage inductance, and the effect of this is to cause voltage spikes across the switching transistors. To counteract this, a snubber (damping) network consisting of resistor R4 and capacitor C2 are connected directly across the primary winding of transformer T2. Keep the leads connecting R4 and C2 as short as possible to avoid creating a parasitic resonant circuit across the transformer. If transformer T2 is carefully constructed, the leakage inductance will be minimized, and there will be very little difference seen in the voltage waveform present across transformer T2 with or without the damping network installed.

DC BLOCKING CAPACITOR

Capacitor C1 is used to block any DC component of the pulses from Q1 and Q2 from causing a shift of the operating point on the magnetic hysteresis curve of the ferrite core in transformer T2. A DC component can be the result of a leaky switching transistor, or a problem in the gate drive circuit. If the operating point of the ferrite core shifts excessively, the ferrite core may saturate and excessive current will flow through one of the switching transistors, possibly causing the transistor to fail.

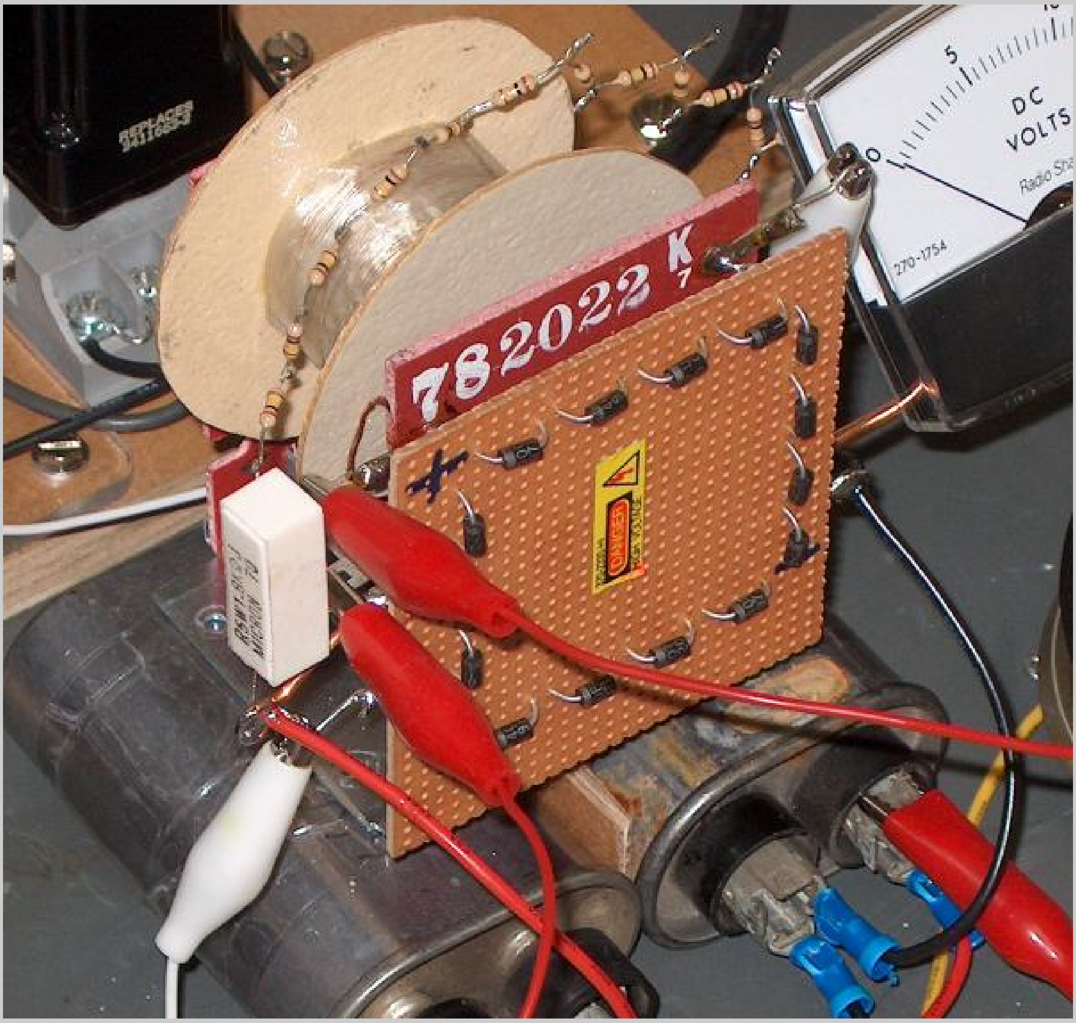
C1 is made from 6 - 2 uF 250 Volt poly film capacitors, for a total capacity of 12 uF. The capacitors were salvaged from old computer power supplies. The exact type of capacitor used here is not critical, as long as the capacitor does not become warm in operation and the waveforms as seen across transformer T2 look correct. (See pictures later in this document.)

C1 has a capacitive reactance of about 0.5 Ohms at the operating frequency of 27 kHz.

HIGH VOLTAGE OUTPUT CIRCUITRY:

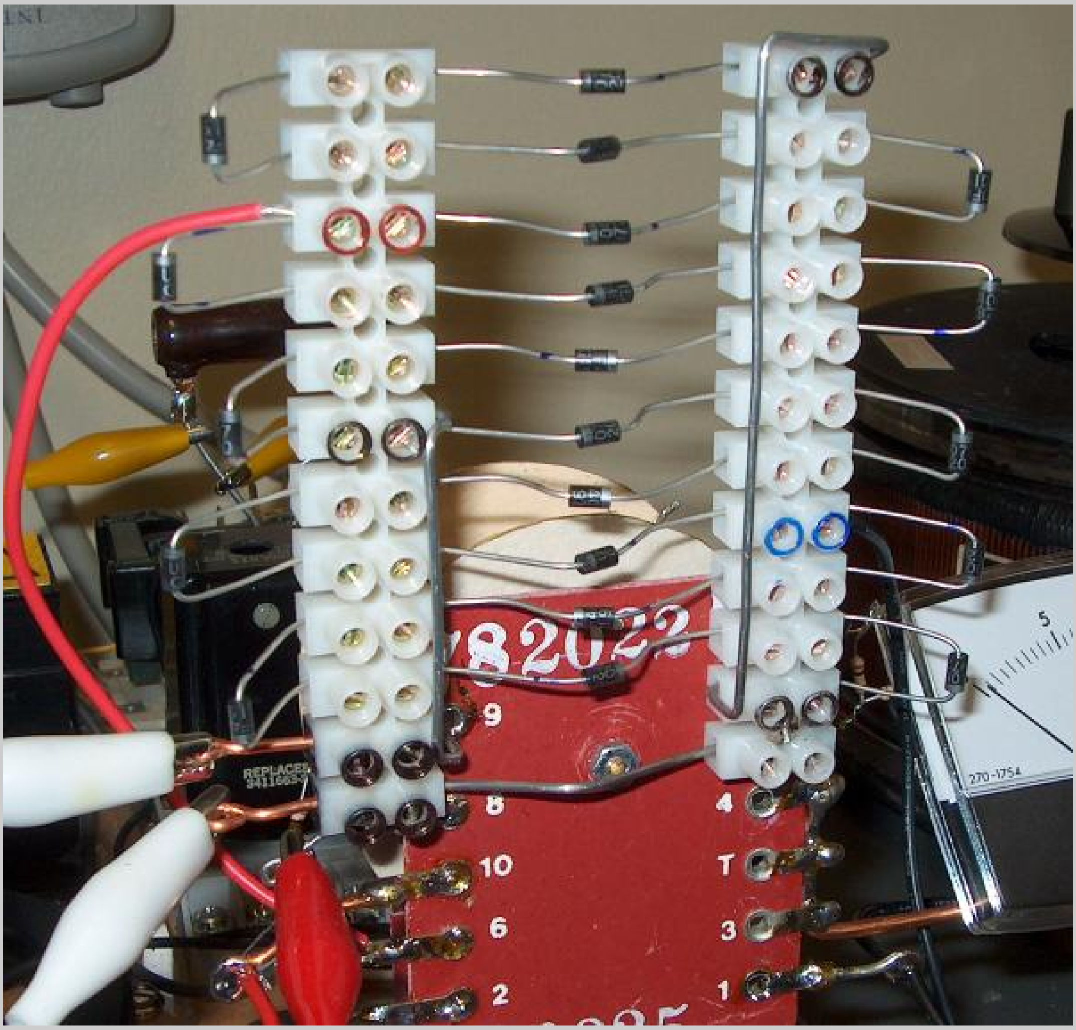
The 1,600 VAC is then full wave bridge rectified by a bank of 20 - UF4007 high frequency high voltage diodes and choke input filtered by inductor L1 to 1,500 volts DC. The high voltage filter capacitor C6 is of small capacity (2 - 6 uF) by normal standards, but the small capacity limits the amount of stored energy in the event of an internal amplifier tube arc or a high voltage to earth fault path. Voltage ripple is not a problem because any ripple resulting from the high operating frequency of the switching supply is effectively filtered out by filter capacitor C6, and any 60 or 120 Hz ripple from the mains power is regulated out by the PWM circuitry.

HIGH VOLTAGE RECTIFIER:



My first try at the high voltage rectifier - 16 - UF4007 diodes in a full-wave bridge configuration.

This arrangement lasted until I started testing at about 1,200 volts and 500 mA load. At that point, all of the diodes in one leg of the bridge shorted and the power supply shut down. I thought this was rather strange, since the voltage rating of each diode was 1,000 volts, and the current rating was 1 ampere. I had individually tested each diode before assembly and verified that each one would handle at least 1,000 volts before breaking down. I also had noted that the diodes became pretty warm - well, quite hot, to be exact - while in operation.



The Second High Voltage rectifier.

Back to the drawing board. I suspected that the cause of the failure might be a voltage spike, so a second bridge rectifier was constructed.

For my second try at making a bridge rectifier, I used a total of 20 - UF4007 diodes, 5 diodes per bridge leg. I assembled the bridge between a pair of screw-type terminal strips. This made it much easier to replace a diode should one fail, and also made making connections to the rectifier assembly very easy.

I also left the leads of each diode full-length for cooling, since, according to the diode manufacturer, most of the heat is removed from the body of the diode through the leads. Figuring that the copper leads were a fairly good heat sink, I bent the diode leads in a zigzag shape so that when the bridge was placed in an upright position, cooling air would be able to freely flow between and around each diode lead for the best cooling effect.

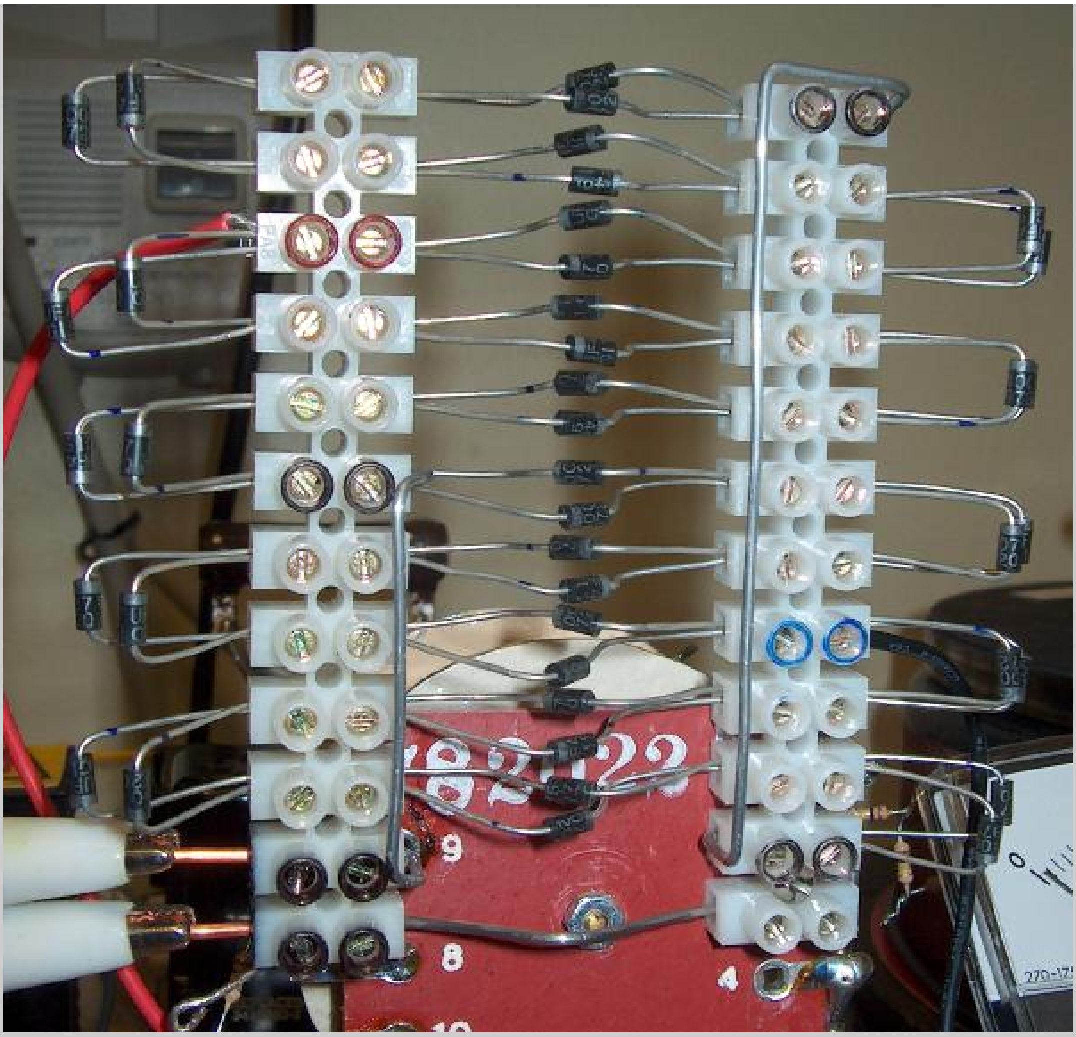
Although this bridge rectifier seemed to work correctly, it still got rather hot. I investigated and found that the losses were not what I had expected. At 60 Hz, where most of us have had power supply experience, most of the loss in a solid state diode is simply the I^R loss in the diode when it is conducting in the forward direction. At high frequencies, however, things are quite a bit different. There is another loss component in a semiconductor device such as a diode, and that is the losses that occur when the device turns on and again when it turns off.

Each semiconductor device has a fairly constant time which is required for the device to turn on and turn off. During the transition periods, the device resistance is higher than when it is turned completely on, and so during the transition time the I^R losses are quite high. This time is quite short, usually in the range of 25 - 100 nanoseconds. The thermal energy created during these transition times are averaged out in the physical mass of the diode and appears as part of the temperature rise during operation.

At 60 Hz, the total of the transition times per second is very low, but at 27,000 Hz where this power supply operates, the total of the transition times per second is 450 times larger. This causes the total transition time losses to increase by 450 times, which causes the diode to experience a considerable increase in temperature when operated at 27,000 Hz.

There's something else to consider, too. I found that if I operated the power supply at 1,000 volts at 500 mA, the diode bridge got quite a bit hotter than it did if I operated the power supply at 1,500 volts at 500 mA. At first, this did not appear to make sense, but then I remembered that the voltage drop across a diode increases in a non-linear manner as the current through the diode increases. But the power supply is supplying the same current to the load in both cases even though the voltage is different. And the current has to pass through the diodes, so what's happening?

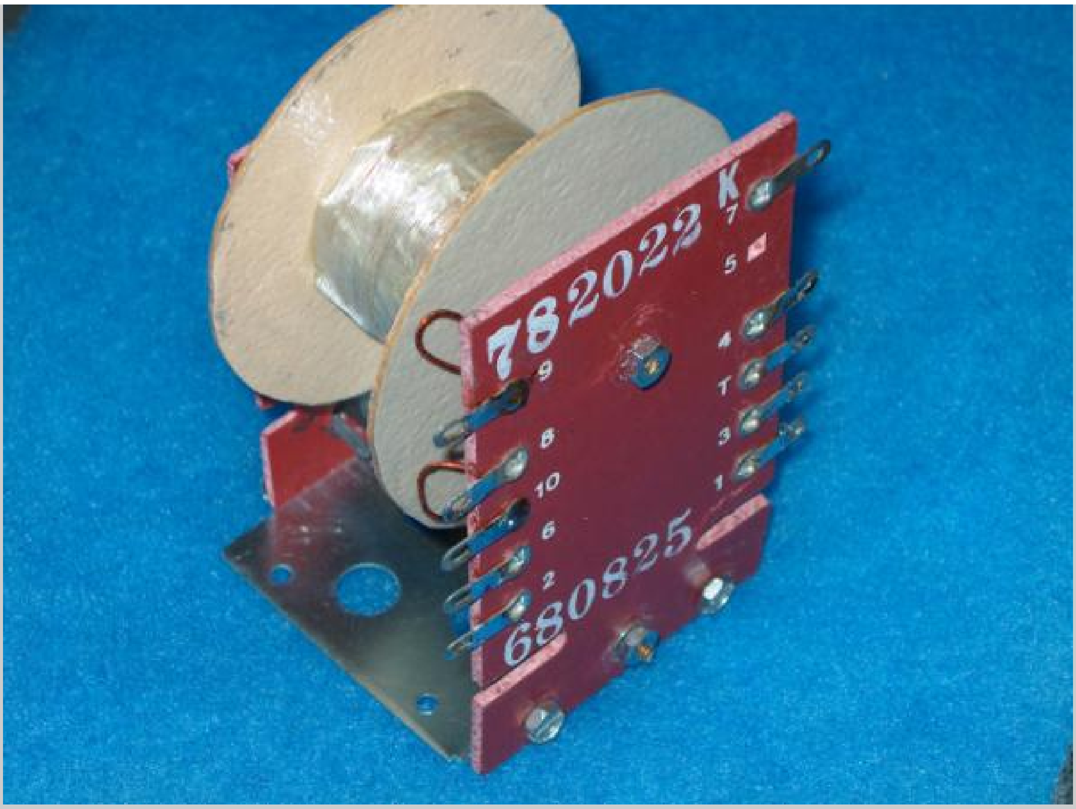
When the power supply is running at 1,000 volts output, the switching transistors Q1, Q2 are turned on for less time than they are when the supply if producing 1,500 volts output. (A lower output voltage or current means a shorter switching time.) At first glance it would seem that the diodes should run cooler at 1,000 volts, since they are carrying current for a shorter time each cycle. But, the transistors supply current in pulses, and those pulses are smoothed out by choke L1 to produce the average 500 mA output current. Although the diodes are conducting for a shorter length of time, they are carrying a higher current during that time. There has to be enough current supplied to the rectifier diodes in each switching pulse so that when the pulses are smoothed out by the filter network, the average power will be correct. Because the voltage the transistors switch into the transformer is fixed at +/- 130 volts, the current supplied to the filter network must be greater if the switching pulse is narrower but the load current remains the same. (Trust me; it works that way.) Since the diode I^R losses rise disproportionately as the current increases, the diodes can overheat at what appears to be a safe current level.



The Third Time's The Charm.

The fix turned out to be simple; just parallel another set of diodes with the first set, as shown in this picture. This works without any balancing resistors in series with the diode strings because if any string of diodes carries more current than the other parallel string, the higher current will cause a greater voltage drop across that diode string, causing the other diode string to automatically increase its conduction, thereby tending to equalize the current flow through the parallel diode strings.

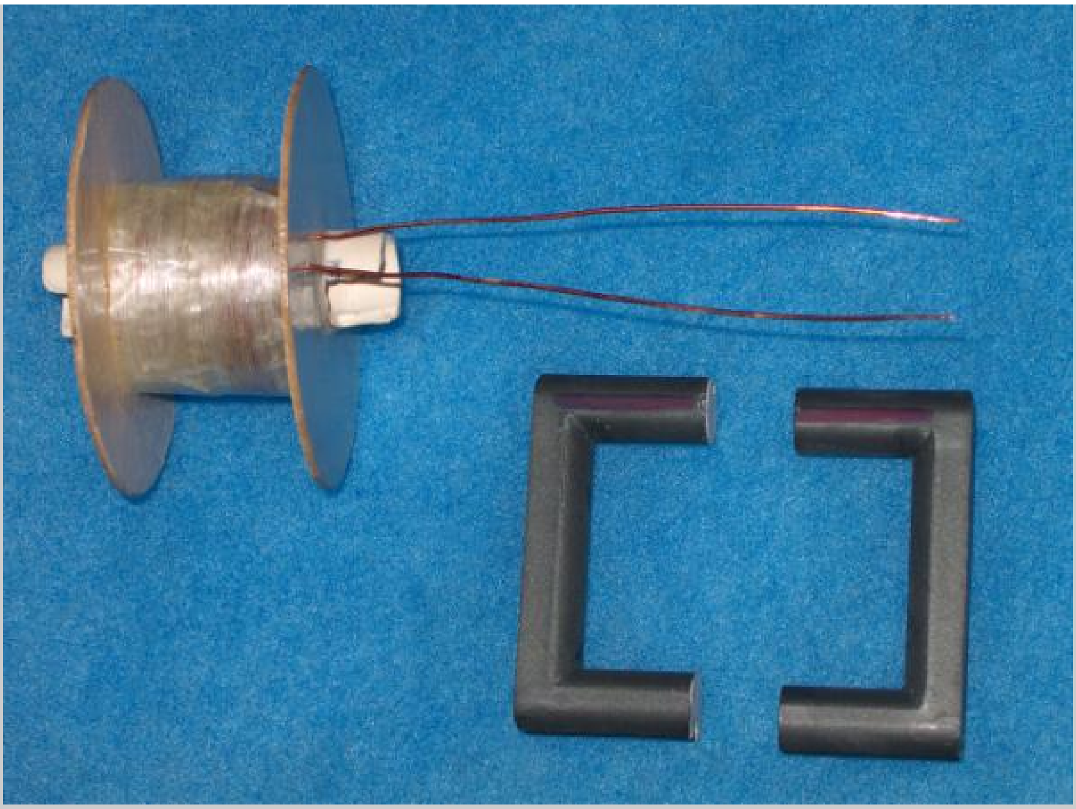
HIGH VOLTAGE FILTER:



Smoothing Inductor L1 ready for installation.

Now that the 1,600 volts AC has been converted into pulsating DC, it will be filtered into pure DC by inductor L1, and capacitor C6, which is not shown here. The filter network is a choke input filter. Do not use a filter capacitor on the input of the L1. A capacitor in that position will behave as a short circuit between the output of the bridge rectifier and ground . This will cause the supply to immediately shut down due to excessive switching transformer current.

Choke inductor L1 was constructed from an old LOPT (horizontal flyback transformer). All the windings were stripped from the core and a new coil form was constructed to fit the core much in the same manner as was done for switching transformer T2. The core of L1 is about 1 cm^2. in cross-section, and is probably made from #43 or #77 material. Whatever it is, the material is acceptable for our purpose, since the power supply operates in the same frequency range as the LOPT originally used.



The finished choke coil and the two halves of the ferrite core.

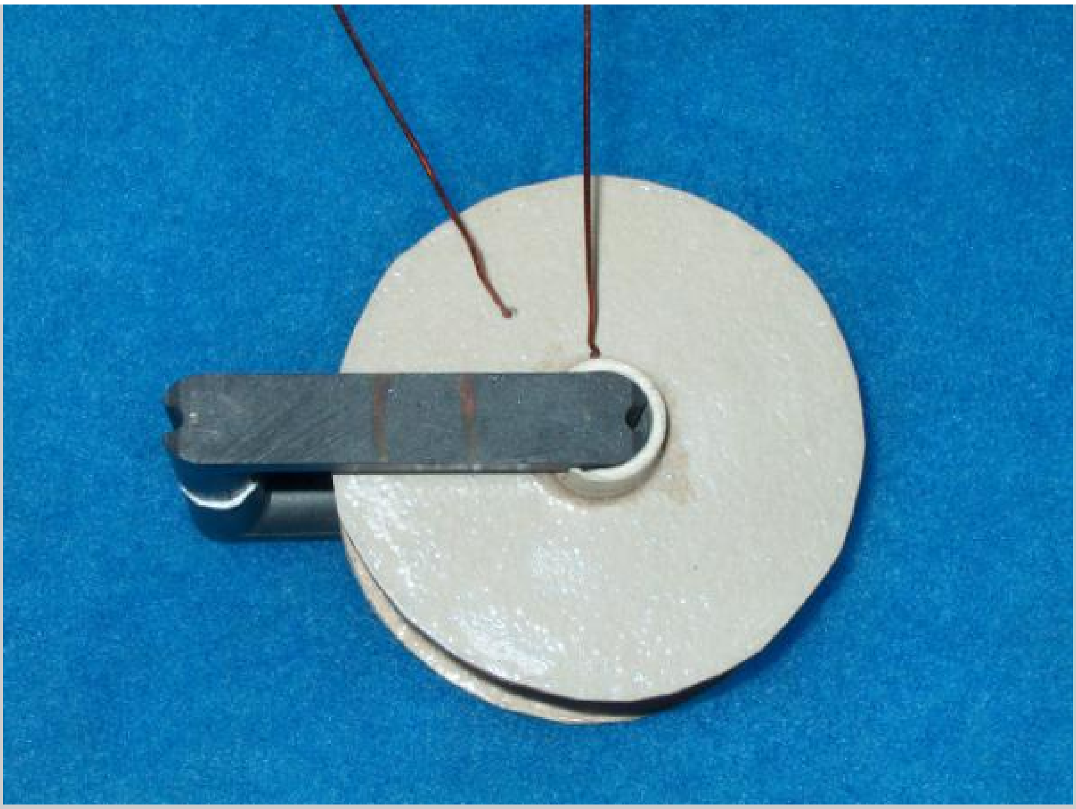
After constructing the coil bobbin, it was wound with about 245 turns of # 21 AWG enameled wire, close wound. Each layer was covered with two layers of insulating tape, and the next layer was wound in place. No special winding method was used; the winding layers were simply wound back and forth until the required number of turns were wound.

Using the power supply design formulas which are found in the ARRL's Radio Amateur Handbook, the critical minimum inductance required for proper filtering was calculated to be close to 9 mHy. Less inductance would fall below the critical value of inductance at the minimum design load current of 75 mA, possibly causing voltage regulation problems. When it was finished and tested, inductor L1 had an inductance of 56 mHy with both of the the ferrite core sections in place and no air gap between the core sections.

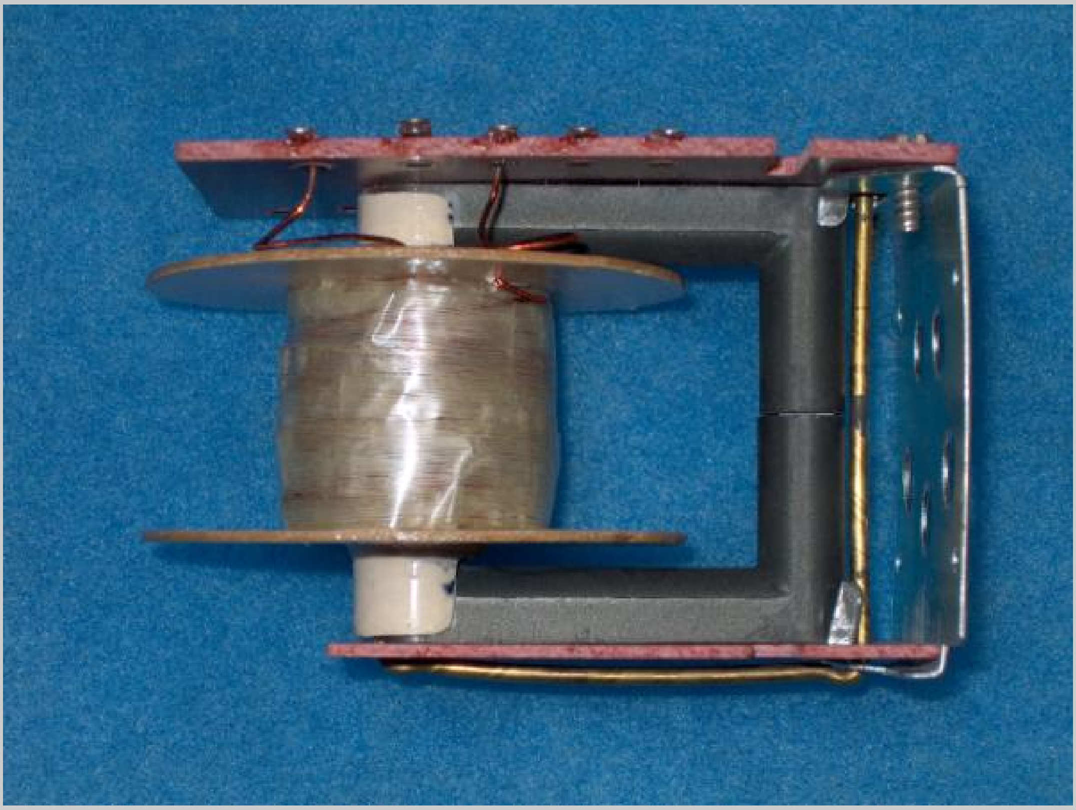
I knew that it would be necessary to provide a small air gap between the ferrite core sections in the finished inductor to prevent core saturation when the inductor was carrying 750 mA at full load. That meant that the inductance of the finished coil would have to be greater with the core sections in place and no air gap between them. Some rewinding was required to determine the correct number of turns for the completed coil.

Inserting two thicknesses of a business card between the opposing ends of both sides of the two core sections was sufficient to reduce the inductance to 11.6 mHy after the core sections were placed against each other inside in the coil. This was above the critical inductance of 9 mHy, so I knew that the choke inductor would work properly. Higher inductance than the minimum required is good, less is not good. One of the two air gaps is seen in the picture below and is visible as the thin white line in the center of the right hand core leg. The other gap is hidden inside the center of the coil form.

The exact number of turns and the spacing of the air gap will need to be adjusted in your unit, and will depend on the type of core material and size of core you have available. The picture below shows the finished coil with the ferrite core sections inserted into the coil form.



Core sections inserted into the finished coil. Note the paper spacers between the core sections.

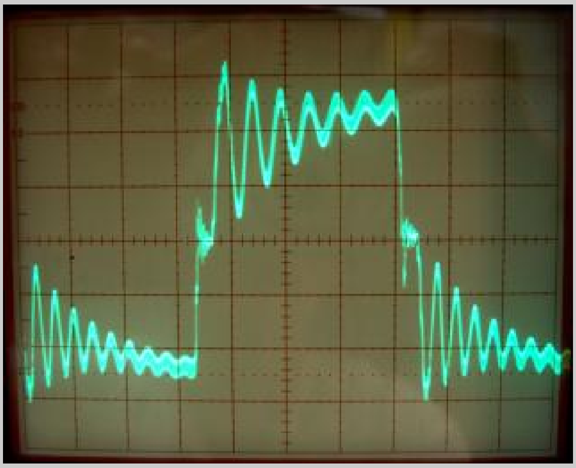


Side view of the completed choke coil L1.

DAMPING NETWORK:

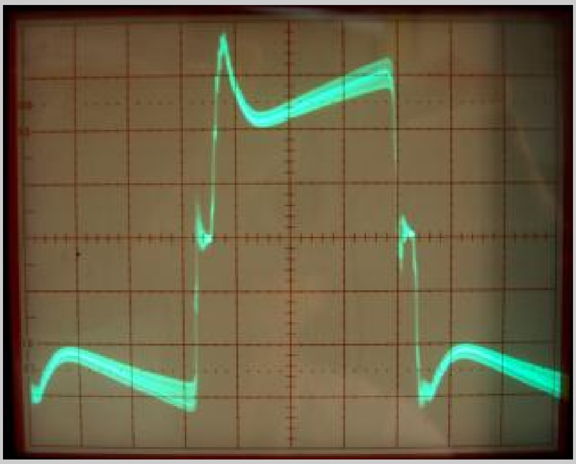
When a voltage square wave is applied across an inductor, as is the case when the high voltage bridge rectifier diodes begin conducting at the beginning of each power switching pulse, the voltage charges the self-capacity of the coil. This causes the inductor and its self-capacity (which form a parallel resonant circuit) to begin a damped oscillation, in much the same manner as a bell rings when struck by a hammer.

This transient oscillation also causes the current flowing through the inductor to oscillate as well. This ringing is also reflected back into the current waveform in the primary and secondary windings of T2. This ringing will make the current supplied by the switching transistors during each switching pulse very irregular, possibly exceeding the maximum allowable current the transistors can handle. Under severe ringing conditions, the current flow will actually try to reverse and flow backwards from transformer T2 into transistors Q1 and Q2. Diodes D3 and D4 will attempt to clamp this reverse voltage. This will cause excessive current to flow through transformers T2 and T3, triggering the automatic shutdown circuit.



No damping network across L1. (Full power)

This is what the current waveform through T2 and L1 looks like with no damping network installed across L1. In this picture, the power supply is running at full load. Notice that after the current rises to the maximum on the first half cycle, it swings negative towards zero (at the middle line on the oscilloscope screen). If it were to go below zero to a negative value, it would cause one of the diodes across the switching transistors to conduct, triggering an overload shutdown. A damping network must be installed to suppress this severe ringing. The damping network is composed of resistor R5 and capacitor C5.

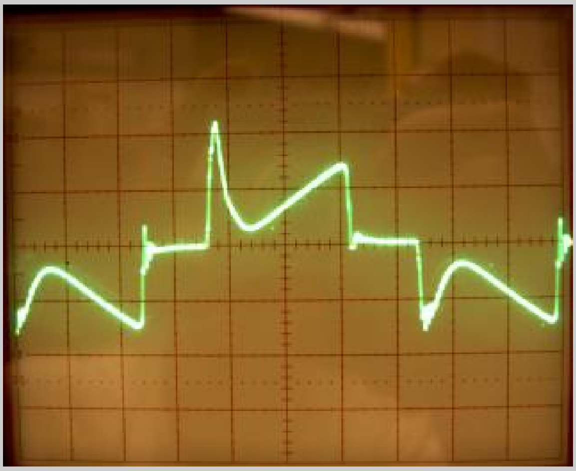


Optimum value damping network across L1. (Full power)

Here you see the difference in the current waveform when the correct damping network has been connected across L1. In this picture, the power supply is running at full load. The first half cycle of the oscillation is still present. It will be there, because this represents the current necessary to charge the self capacity of the inductor. But notice that the remainder of the

waveform has been modified so that all that remains of the damped oscillation which was visible in the first picture is just a smoothly rising waveform. Except for the capacity charging half cycle, this is pretty much the classical trapezoidal waveshape you see for current flowing through an inductor when the inductor has a square wave voltage applied across it.

NOTE: If you tweak the damper network values, you can get the current waveform to become an almost perfect square wave, however, this is incorrect, and is not what you want to happen. What will happen is that the damper resistor will get very hot, since it is dissipating the extra power represented by the area under the curve which was "filled in" by changing the current waveform from a trapezoid to a square wave. You will also find that the mains power required by the power supply will increase, indicating that extra power is going somewhere. It is - but not to the load - it's all going to heat the damper resistor.



Optimum damping network across L1. (Half power)

Dropping the load on the power supply to about half power results in the average current decreasing during the switching pulses. The pulse length is also shorter, indicating that the transistors are supplying less power to the switching transformer. Note that the initial charging current still peaks at about the same height as it did at full load. This is because the pulses, although of shorter time length, are the same voltage level at half load and at full load. In fact, the voltage will be the same at any load.

Optimum damping network across L1. (One-quarter power)

In this picture, the power supply is running at one-quarter load. The pulse length is shorter still, and the average current is also slightly less. This waveform is pretty much what you should see when the damping network components are correctly chosen.

To determine the optimum values of the damping network components, a couple of "rules of thumb" are:

1) The lower the resistance of R5, the flatter the waveform will be - but the losses will also be larger - so keep R5 as high resistance as possible.

2) The greater the capacity of C5, the more damping effect it will have on the first cycle of the ringing. Note that too low a value of R5 will cause C5 to form a parallel resonant circuit with L1 and make the ringing worse. Too small a value of C5 makes R5 ineffective at changing the slope of the waveform. C5 should be as small as possible while still removing most of the oscillation from the waveform, except for the first half cycle.

You may also obtain a close approximation of the correct values by using the following formulas:

*Calculate the XL of L5 at (2 * Switching Frequency)*

*XC of C5 = (2 * XL)*

R5 = XL

In this case:

L5 = 10 mHy

*(2 * Switching Frequency) = 54,000 Hz*

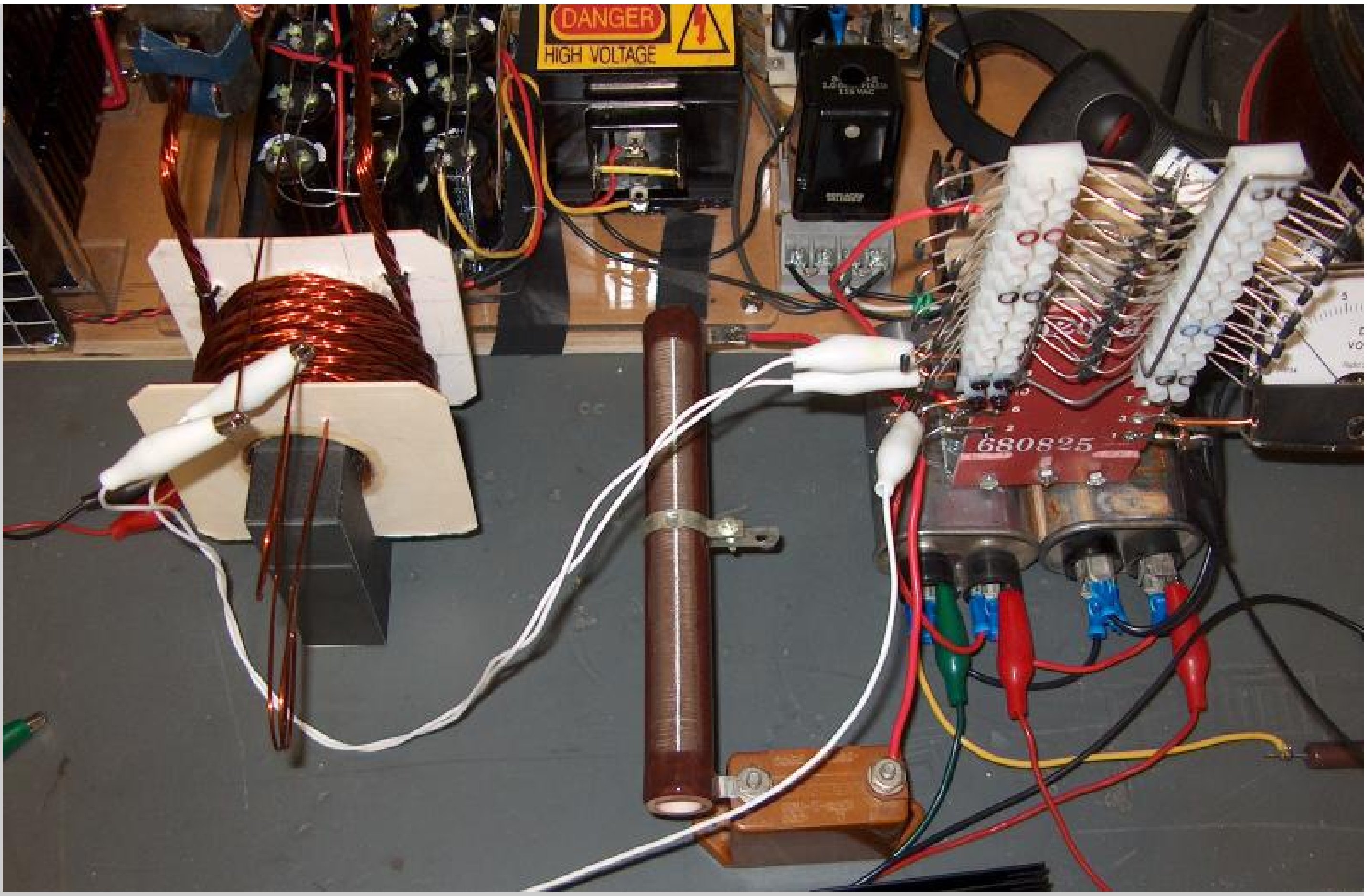
Using the Reactance Chart in the ARRL Handbook we find that:

XL = 2,500 Ohms

XC = 5,000 Ohms, or about 600 pF

R = 2,500 Ohms

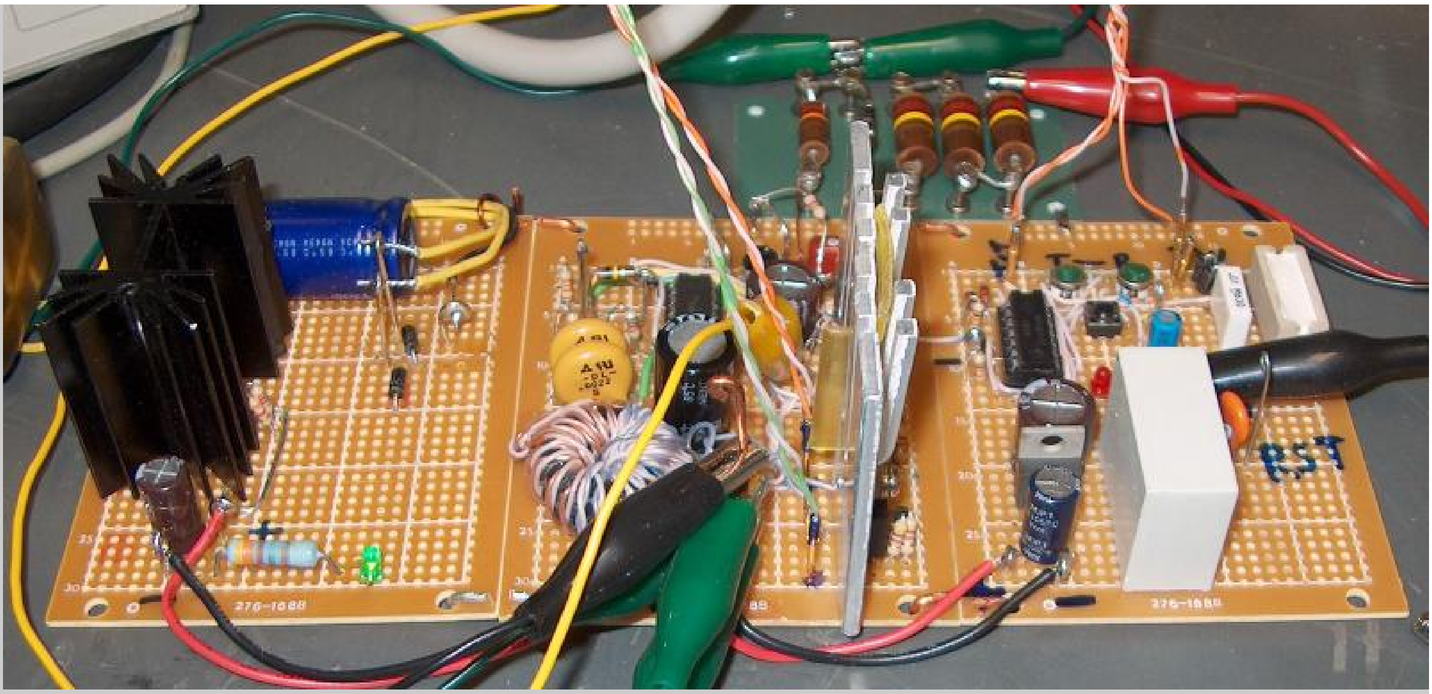
The power rating of R5 must be determined experimentally. If it burns up, it was too low a wattage.



Switching transformer, high voltage rectifier and filter, and damping network.

The picture shows the switching transformer, which is connected with the white clip leads to the high voltage bridge rectifier. The rectifier assembly is mounted on the frame of choke L1. Beneath L1 are the high voltage capacitors which make up C6. The large brown power resistor is the damping resistor R5, and the brown cased Mica capacitor connected to R5 is snubber capacitor C5. Capacitor C6 is an ordinary oil-filled metal-film paper capacitor. I used several high voltage capacitors salvaged from old microwave ovens. These were placed in parallel to obtain the required capacity.

PWM CONTROLLER AND REGULATOR:



The Pulse Width Modulator and Safety Logic assembly, with power supply.

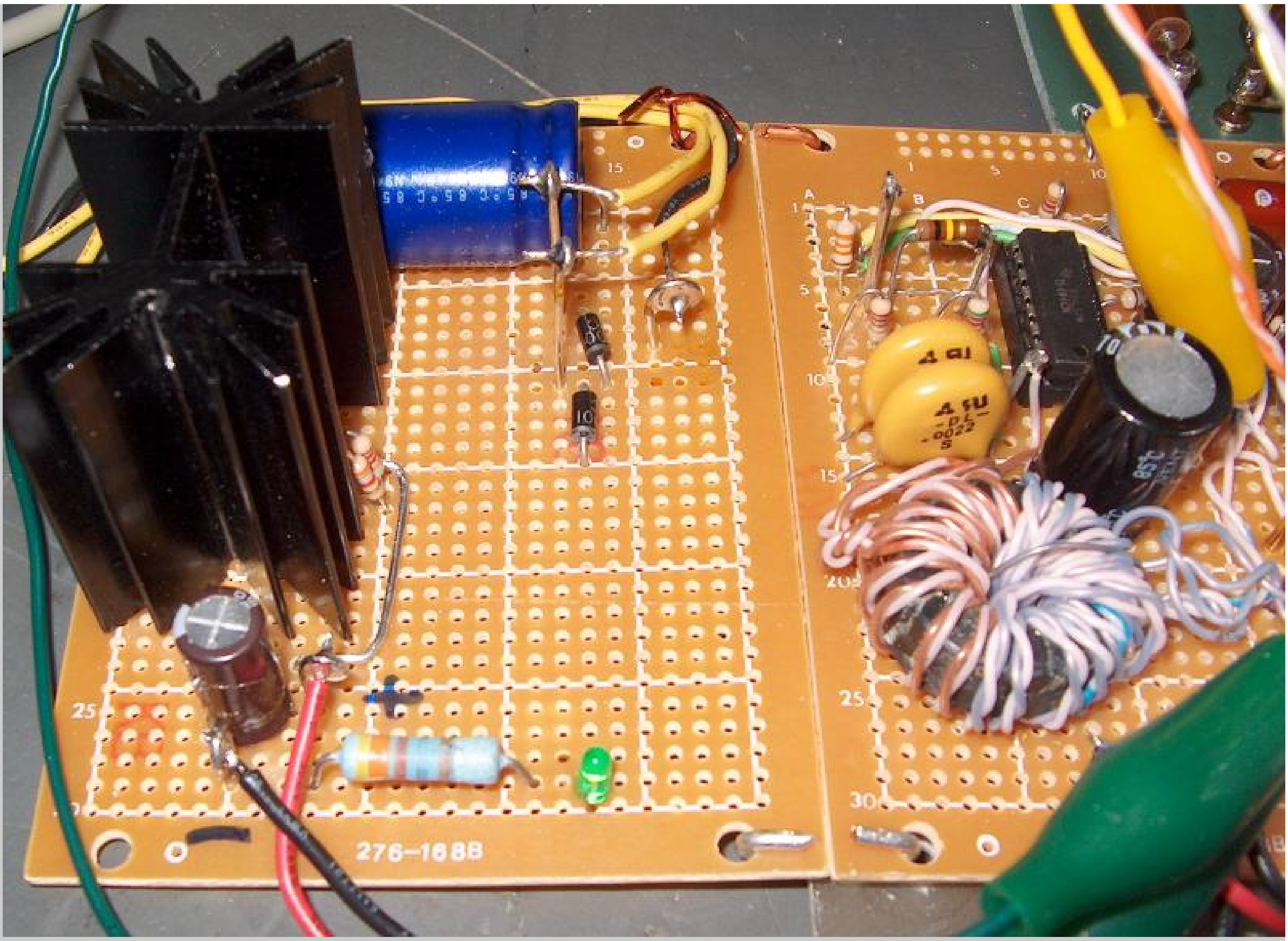
To regulate the power supply's output voltage, pulse width modulation (PWM) controller U1 samples the rectified and filtered 1,500 volt output of the supply and compares it to a stable reference voltage. As either the mains voltage or the connected load changes, the PWM controller adjusts the pulse width (also called the "duty cycle") of the gate drive signal sent to the main switching transistors Q1, Q2. This variation in pulse width turns the switching transistors on and off for varying durations, so that the DC output of the power supply always matches U1's internal reference voltage. This causes the output of the power supply to remain very close to the set point of 1,500 volts (or whatever you have set it for.) A special high voltage Zener diode, ZD2, with approximately 1,000 volts rating is used in the voltage regulation feedback circuit to improve the voltage regulation. This is an optional component, but the voltage regulation is somewhat poorer without it.

DETAILED PWM CIRCUIT DESCRIPTION:

The PWM circuit consists of IC U1, which does the actual pulse width control and voltage regulation functions, and IC U3 which serves as the control logic for the safety shutdown system. Because the PWM and safety circuits must be ready at all times, they are operated from a separate power supply transformer.

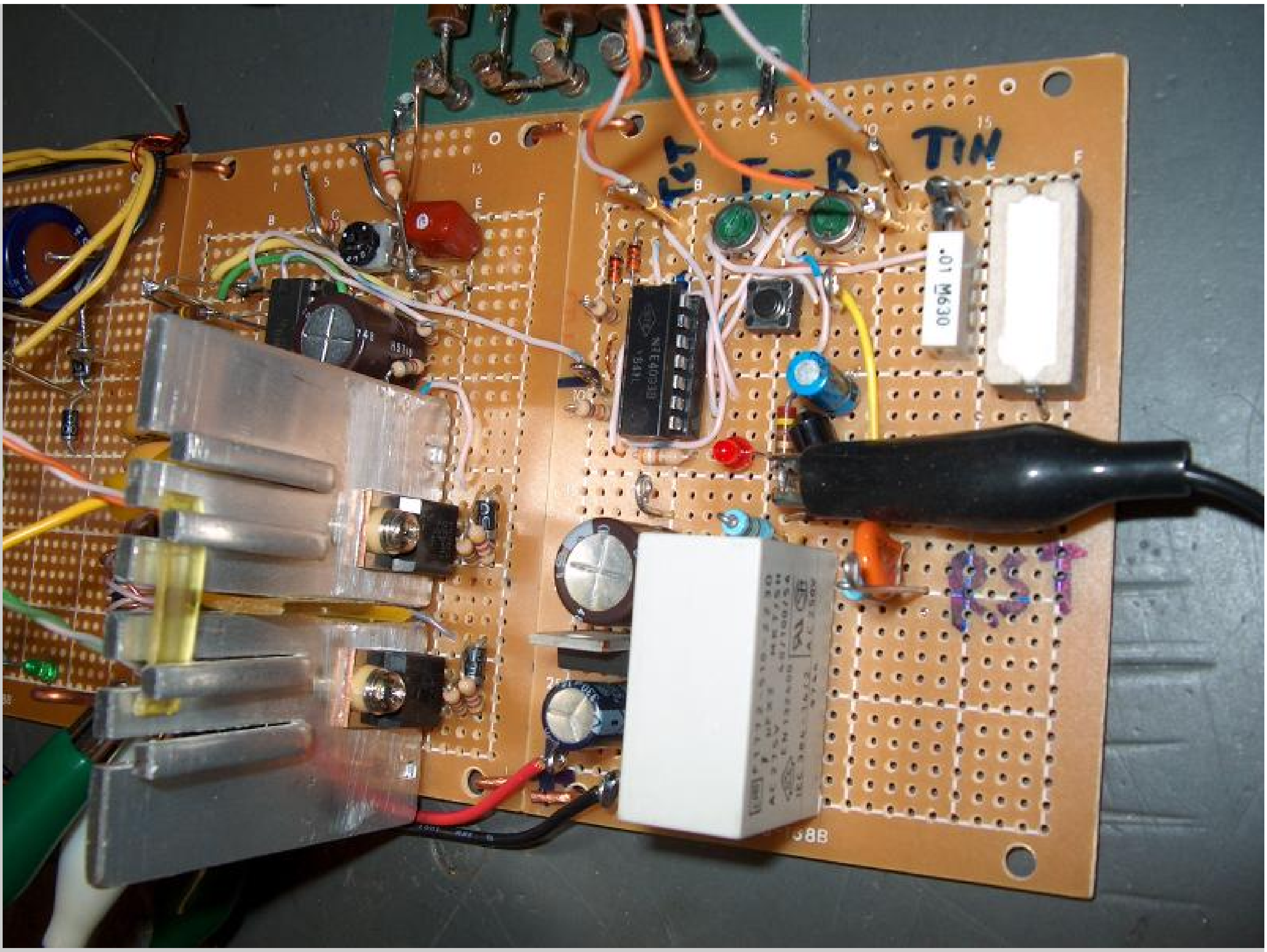
Power transformer T4 supplies 24 VAC center tapped which is full wave rectified by diodes D45 and D46 and filtered into +18 VDC by filter capacitor C12. Three-terminal adjustable voltage regulator U2 is trimmed by resistors R21 and R22 to regulate the +18 VDC down to +10.5 VDC. The +5 VDC is used to operate PWM IC U1. U2 is attached to a heat sink. Capacitor C11 serves as the output filter capacitor for the +10.5 volts produced by U2. Both capacitors C12 and C11 must be placed close to U2 to prevent possible oscillation in the +10.5 volt buss. LED D47 and current limiting resistor R23 are used to indicate the presence of the +10.5 VDC power. These are optional components.

Note that 10.5 volts is used instead of something more "normal" such as 12 or 15 volts. This is because U1 cannot handle a higher voltage than 10.5 without overheating when it is operating at maximum pulse width. This is because it must supply several watts of gate drive power to the driver circuits for the IGBT switching transistors.



Left - Power Supply, right - PWM controller U1 and transformer T1

Power for U3 is supplied by fixed +5 volt regulator U4. Because of the low current required by U3, no heat sink is needed for U4. Capacitor C15 is the input filter capacitor for voltage regulator U4 and capacitor C16 is the output filter capacitor. . Both capacitors C15 and C16 must be placed close to U2 to prevent possible oscillation in the +10.5 volt buss.



Right-hand board - Safety Shutdown circuits, left-hand board - PWM controller and transistor drivers Q3 and Q4 seen here mounted on their aluminum heat sinks.

PWM IC U1 generates an internal sawtooth wave at 54 KHz, which is twice the switching frequency of 27 KHz. The sawtooth frequency is determined by the values of R15 and C8. This sawtooth is used as one of the inputs to a pair of internal voltage comparators, one of which monitors a voltage sample from the +1,500 volt line, and the other, which looks at the output of the safety shutdown circuit, U3. Filter capacitor C9 must be placed close to U1 and connected with short leads to prevent possible unwanted oscillations.

An internal +5 VDC reference voltage is generated on pin 14 of U1. This is divided by resistors R24 and R25 to create a +2.5 VDC reference signal. The +2.5 VDC reference is sent to the - input of both of the internal comparators on pins 2 and 15.

Pin 3 is a compensation feedback output signal, which is mixed with the +2.5 VDC using resistors R13 and R12. This reduces the gain of the comparators from 80 dB to about 16 dB. This is sufficient gain for the regulator to function properly, but not enough gain to cause unwanted feedback and circuit oscillation.

To make sure the power supply has a "soft" start-up, capacitor C17 and resistors R31, R32 and R33 provide a controlled voltage ramp on U1 pin 4 that falls from about +4 volts to zero about three seconds after relay contact K1b closes. R14 helps keep stray noise out of pin 4. This falling waveform allows the pulse width signal which is sent to the switching transistors to gradually increase in width over the three second start up interval, and this gradually brings the output of the power supply up to full power over three seconds. Opening relay contacts K1b allows capacitor C15 to recharge within about 1/2 second, and rapidly brings the power supply's output down to about 10%.

PWM OUTPUT DRIVER CIRCUIT

After the pulse width modulated switching drive pulses have been generated by U1, they are used to drive the gates of transistors Q1 and Q2. The base of commonly used bipolar transistors present a mostly resistive load to the driving circuit, but IGBT's are quite different. Just like a MOSFET, IGBT's present a very high resistance load to the driving circuits, and, also like a MOSFET, they present a fairly large capacitive load to the driver.

For all practical purposes, the gate of an IGBT is a capacitor. This makes the gate drive circuitry somewhat more complicated than it would be if we were using bipolar transistors. To add to the complications, the operating characteristics of U1 also affect the required drive circuitry.

If you look at the diagram of the driver circuit between the output of U1 and the gates of the IGBT's, you will see that the circuit is a moderately complex push-pull drive system. Let's analyze it in detail.

The first thing to notice is that the secondary side of T1 has two identical windings. Each winding is used to drive a separate IGBT. Separate windings are used because the emitter of Q2 is at -130 volts, and the emitter of Q1 is at either + or -130 volts, depending on whether Q1 is on or off. This makes a common reference connection for both IGBT's impossible, and so we need separate drive windings on T1.

The primary of T1 is center tapped, with the center point of the winding connected to the +10.5 V power buss. Each end of the primary winding is connected to its respective output connection from U1. The output stage in U1 is capable of supplying 2.5 watts of power through T1. Each of the output transistors in U1 provides one of the two switching drive pulses to the primary of T1, and they are combined on both of the secondary windings of T1 and appear as a 27 KHz AC waveform. The waveform appears as a series of alternating positive and negative pulses of variable width.

Notice that the relative polarities of the two secondary windings is reversed, so that when the top of winding 1 is positive with respect to the bottom of winding 1, the top of winding 2 is negative with respect to the bottom of winding 2. This is because the transistors must be turned on alternately, but never both at once, or a short circuit would be placed directly between the + and -130 volt busses.

Now, you might ask just why do we need all of those other components between the secondaries of T1 and the IGBT's? After all, we could just connect one end of the secondary winding to the emitter of each transistor and the other end of the secondary winding to the gate lead of the IGBT. That should work, and it would allow each gate to go positive on its own positive drive pulse, and the transistor would ignore the negative pulse - right?

Sorry, that doesn't work. Remember that the gate appears as a capacitor, and a pretty large one, at that. In fact, the transistors used here represent a 7,000 pF capacity. Since that capacity is essentially placed directly across the secondary windings, what happens is that a very effective parallel resonant circuit is formed by the gate capacitance and the secondary windings of T1.

It's important to understand that the output transistors of U1 are only turned on during the switching cycle for the amount of time required to generate the PWM pulse, and during the remainder of the switching cycle they are turned off. During the transistor off time periods, the primary winding of T1 is effectively open circuited, because there is no damping effect from the driver transistors in U1 because they are not conducting. During this off time, the energy which was pumped into the gate capacitance of the IGBT's will oscillate back and forth through the secondary windings of T1, causing the IGBT's to turn on and off following the oscillating gate signal. This causes the system to overload and shut down. We must stop this oscillation from happening.

We can do this by adding a few parts to the circuit. First, we add a pair of diodes, D25 and D26. These allow the positive drive pulses to get to the gates of the IGBT's. Since the diodes do not allow the gate charge to return to the secondary windings when the gate pulse ends, we have stopped the oscillation from happening. Of course, what will happen is the gates will stay charged positive - the gate capacitors are very high quality, and have very low leakage - and as soon as the second transistor turns on, we find that we now have a dead short through the transistors directly across the + and -130 volt buss. Oops! We need to fix that.

We do that by adding a pair of transistors Q3 and Q4 between the gate and the emitter of both of the IGBT's. The purpose of Q3 and Q4 is to dump the charge on the gate of the IGBT's as soon as the positive drive pulse goes away. This will turn the IGBT's off and dissipate the gate charge energy as heat in the transistors ON resistance. That's why transistors Q3 and Q4 are mounted on heat sinks. Now, remember that I mentioned that during the drive pulse off periods that U1's transistors

are off and provide no signal to T1? That means that there is no power available on the secondary of T1 to turn on Q3 or Q4. So how do we get these to switch on and dump the gate charge?

Resistors R8 and R9 (on Q3) and resistors R10 and R11 (on Q4) form a voltage divider network arranged so that when the positive gate drive pulse is present, transistors Q3 and Q4 will be turned off. (They are PNP transistors, so making the base positive with respect to the emitter turns the transistor off.) When the gate drive pulse turns off, resistors R9 and R11 pull the bases of Q3 and Q4 towards the collector voltage, turning Q3 and Q4 on and dumping the positive gate charge which was put into Q1 and Q2

Resistors R2 and R3 are used to prevent leading edge ringing on the gate drive signal caused by the rapid rise of current through the wire connecting to the gate of the IGBT's.

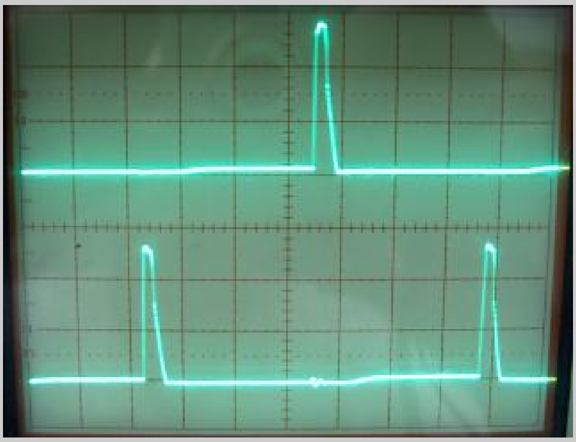
It requires about +5 to +8 volts to turn the IGBT's on. They can tolerate as much as +30 volts on the gates, and +15 volts is recommended by the manufacturer. Transformer T1 provides about 15 volts on each secondary winding, but a volt or so is lost in the driver circuitry. Using a higher voltage would improve the IGBT rise time slightly, but would involve adding an additional set of driver transistors because the output stage in U1 cannot handle any additional output power.

The next two pictures show the waveforms you should see if you connect your oscilloscope probes across the secondary windings of driver transformer T1.

SAFETY WARNING: *The circuits you are measuring do not have the same earth reference for the two transformer windings - they are 130 volts different in potential. The oscilloscope probe shields must be connected to the low side of the driver transformer secondary winding which is connected to the emitter of Q2. This means that the case of the oscilloscope will be at -130 volts DC with respect to earth. Ensure that the case and all connections to the oscilloscope are isolated from contact with anything else, including the operator. It is essential that you use an isolation transformer between the mains voltage and the power supply for operator safety when taking these oscilloscope measurements.*

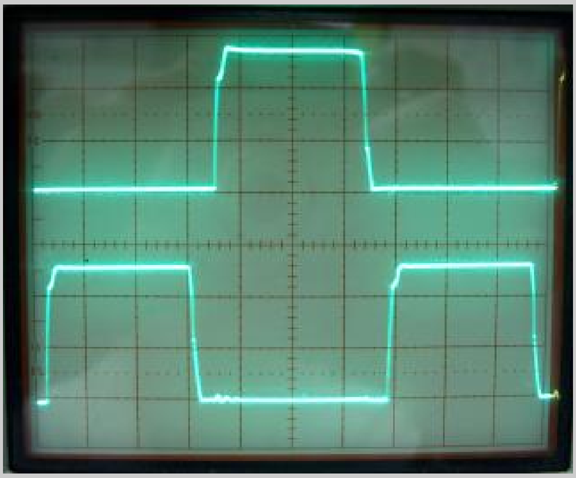
DEATH IS PERMANENT

PLEASE BE CAREFUL!!



Gate Drive at low power = minimum pulse width

This is what the gate drive pulses to the power IGBT's looks like. Notice the very short ON time. The power supply is running in the first part of the three second soft start cycle.



Gate Drive at high power = maximum pulse width

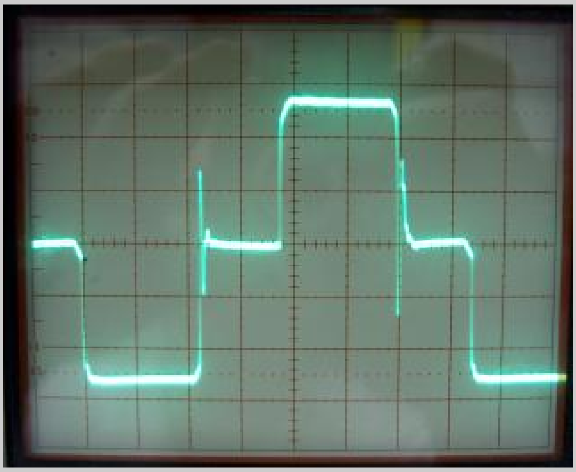
Now the three second soft start time has elapsed and the power supply is running at full load. Notice that the gate drive pulses have widened out to full width. You will note that they are not quite at a 50/50 on/off ratio. This is because we must allow some time for the transistors to turn off before the next one is turned on. The PWM IC handles this, by limiting the ON time to a maximum of 45%. This means that we must design the switching transformer to work as though it were being supplied with a 50/50 square wave but with only about 90% of the actual voltage we have available in our supply. If we don't remember do this, we will find that the output voltage is about 10 to 15% lower than we expect. This is an interesting "Gotcha'!" in switching power supply design, and catches many beginning designers by surprise.

The next two pictures show the waveforms you should see if you connect your oscilloscope probe across the primary of the switching transformer T2.

SAFETY WARNING: *The low side wire from the primary winding of T2 is connected directly to one side of the AC mains. It is essential that you use an isolation transformer between the mains voltage and the power supply for operator safety when taking these oscilloscope measurements.*

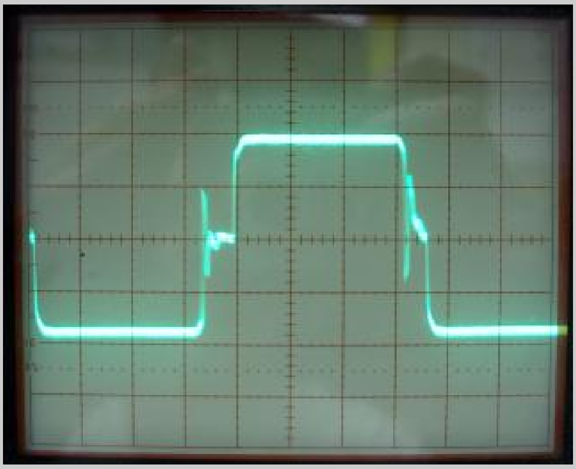
DEATH IS PERMANENT

PLEASE BE CAREFUL!!



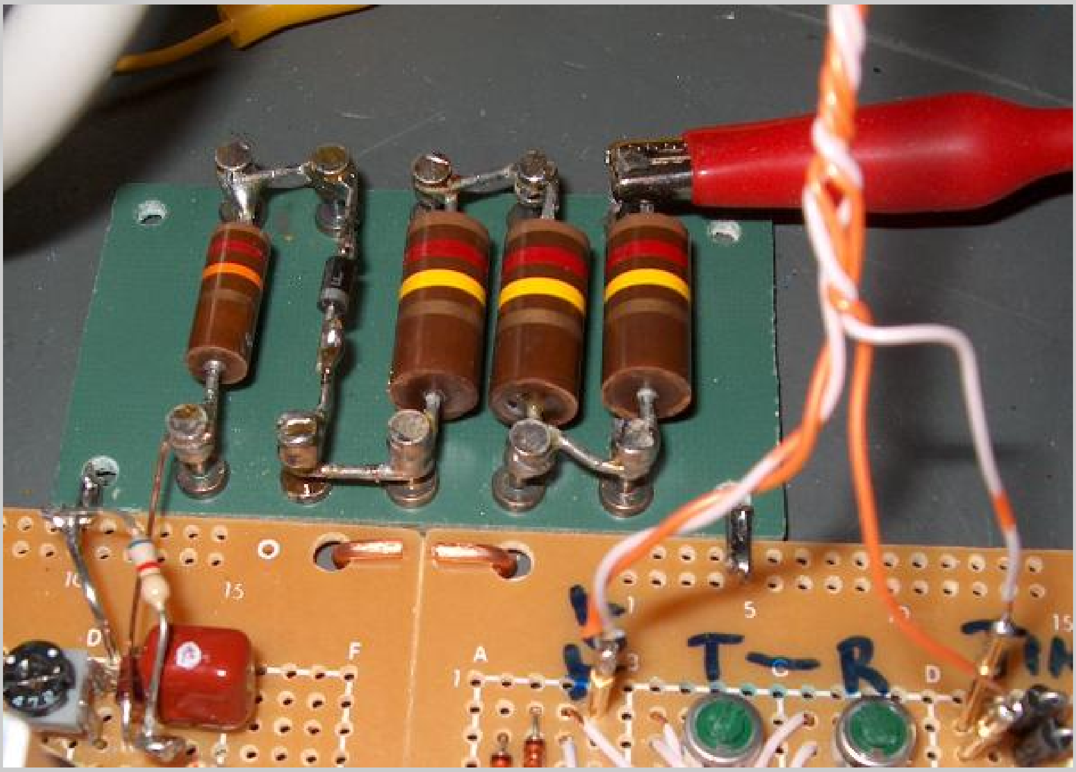
T2 Primary Voltage waveform at low power

Notice that the transistors are conducting for less than the maximum time available.



T2 Primary Voltage waveform at high power

The transistors are turned on for almost the maximum time the PWM will allow.



High Voltage Sense Resistor string and ZD2

HIGH VOLTAGE REGULATION

To accomplish the voltage regulation of the power supply, a voltage sample is taken from the +1,500 volt line through resistors R17, R18, R19, and R20, and Zener diode ZD2. This voltage sample is sent to U1 pin 16. Adjustment of the power supply output voltage set point is done with potentiometer VR1. The span and range of the voltage adjustment set

point are set by selecting R34 and R16. Zener diode ZD1 is a protection diode for U1 in case of a failure of voltage dropping resistors R17, R18, and R19, or in case ZD2 shorts out.

Three two-watt resistors placed in series are used for the voltage dropping resistor string of R17, R18, and R19. Multiple series resistors are used to avoid an excessive amount of voltage from being placed across any one resistor with the chance of a catastrophic high voltage flashover. R20 is optional, and its resistance may be included anywhere in the voltage dropping resistor string. It was placed in the position shown in the diagram to allow me to obtain a sample of the feedback voltage reading during testing.

Zener diode ZD2 requires special mention. 1KV Zener diodes are not commonly stocked by your friendly local parts supplier. So, we shall "roll our own." But, why do we need to use a Zener diode in this voltage divider network anyway, and even if we do, why is such a high voltage required?

It has to do with the quality of voltage regulation we can expect from the power supply. To maintain a constant output voltage, U1 compares the sample voltage from the power supply output to U1's internal reference voltage. The reference we are comparing against is 2.5 volts, which is 600 times smaller. This means that for the smallest voltage change U1 sees as an error signal and can use to regulate with, the voltage change on the output of the power supply must be 600 times larger. For example, if U1 can hold the voltage to within +/- 0.1 volts compared to the reference, than the output of the power supply can change as much as 120 volts and still be within acceptable limits.

If we were suddenly able to "throw away" or "subtract" a large part of the 1,500 volts DC but still keep the output voltage variation and then send that to U1, we would obtain much better regulation. In this switcher, I have used a 1,000 volt Zener diode to "subtract" 1,000 volts from the 1,500 volts. Now, we see that the 1,500 / 2.5 = 600 in our first example has become (1,500 - 1,000) / 2.5 = 500 / 2.5 = 200, or three times less than the first example. We have just improved the voltage regulation of the power supply from 120 volts to 40 volts, or a three-fold measure of improvement by adding one component.

In this power supply, the regulation of U1 is much better than assumed here, and the actual regulation range in this circuit is closer to +/- 0.01 volts.

You can "build your own" Zener diode by carefully reverse biasing common 1N4007 diodes from a high voltage source through a high value resistor - 10 Meg Ohms or so - and measuring the voltage at which the diode begins to conduct in the reverse direction. The best diode will have a "hard" clamping voltage, i.e., the Zener voltage will change very little as the current through the diode varies.

For a PDF file showing the simple test setup needed to determine the Zener voltage of reverse-connected high voltage diodes, please click HERE.

OVERLOAD SAFETY CIRCUITS:

Safety against overloads is provided in the form of load over current detection, and switching transistor overcurrent detection. The protection circuits are fast enough to shut down the power supply within less than 1/2 of one switching cycle in the event an overload is detected. The power supply must be reset from an overload manually.

The safety shutdown circuit consists of IC U3 and associated components. The heart of the circuit is the flip-flop composed of U3c and U3d. Resistors R27 and R28 provide input pull-up voltage to flip-flop pins 1 and 6. To ensure that the flip-flop comes up in the correct state at power on time, capacitor C7 and resistor R35 provide a power on time delay low-to-high transition which holds pin 6 of U3d low long enough for the flip-flop to start up in the correct state.

A high to low signal from either U3a or U3b will be gated through diodes D50 and D51 to pin 1 of U3c. This low will cause the flip-flop to change states, and forcing U3d to go low, lighting LED D54 which indicates to the operator that an overload event has happened. At the same time, pin 3 of U3c will go high, setting pin 1 of U1 high, turning off U1, which removes the gate drive from switching transistors Q1 and Q2, effectively turning off the power supply.

RECOVERY FROM AN OVERLOAD - Method 1

If the power supply is wired so that power to the PWM circuits is turned OFF when switch S1 is opened, then the power supply must be reset from an overload by:

1) Shut off the mains voltage by opening switch S1.

2) Wait about 30 seconds for the 130 volt capacitors to discharge.

3) Close S1 to restore the mains power.

RECOVERY FROM AN OVERLOAD - Method 2

If the power supply to the PWM circuits remains ON when switch S1 is opened, then the power supply may be reset from an overload by:

1) Shut off the mains voltage by opening switch S1.

2) Wait about at least 10 seconds for the 130 volt capacitors to partially discharge.

3) Press the Overload Reset switch and release it. (The overload LED should go out.)

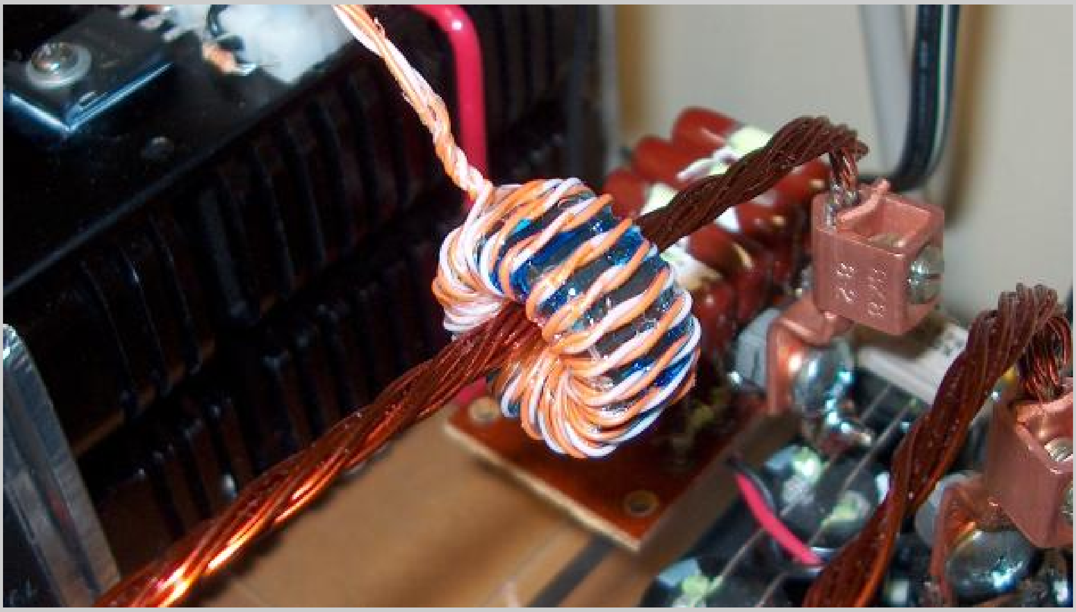
34 Close S1 to restore the mains power.

Note that shutting off the power to the PWM circuit automatically resets the overload flip-flop. If the PWM power remains on, then pressing the manual reset button is required. Using the manual reset could potentially be damaging to the power supply should there be a shorted switching transistor. The manual reset circuit prevents "jamming" of the reset circuit by holding down the reset button and attempting to force the power supply to restart in the event an overload still exists.

OPERATION OF THE MANUAL RESET CIRCUIT

One plate of capacitor C18 is held at +5 volts by R28, and the other plate is also held at +5 volts by resistor R34. This means that C18 is effectively discharged. When the overload reset switch is pressed, one side of C18 is pulled low. This forces the other side of C18, which is connected to U3d pin 6, to be pulled low, resetting the overload safety flip-flop U3c and U3d. This low remains on U3d pin 6 until C18 charges.

The time required for C18 to recharge through R28 is less than 10 microseconds. This ensures that the reset pulse "goes away" very quickly so that the flip-flop can be tripped again if an overload still exists. In other words, the reset pulse ends so fast that before the next power on switch pulse from the switching transistors is more than half done, the flip-flop can shut down the transistor that is trying to turn on again, thereby saving things from a catastrophic failure.



Switching Transistor Over Current Sample Transformer T3

PROTECTION AGAINST SWITCHING TRANSISTOR OVERLOAD

Transformer T3 is used to protect the supply from overloads caused by excessive current through the primary of T2, and also to shut down the supply in the event of a shorted IGBT transistor.

One lead of the primary winding of switching transformer T2 makes a single pass through T3. This single pass forms the primary winding of T3. This means that any current flowing in the primary winding of transformer T2 will induce a voltage into the center tapped secondary winding of T3. This voltage, which represents the current flowing through the primary of T2 appears across load resistor R26 and is full wave rectified by diodes D48 and D49. Because the signal is at 27 KHz, type UF4007 diodes are used. The rectified DC signal is filtered by C13 and appears across potentiometer VR2.

WARNING: Resistor R26 MUST be connected across the secondary winding of T3 at all times. This is because T3 is a current transformer. If the secondary of a current transformer is not connected to a load (that is, if it is "unburdened") the voltage across the open secondary winding may reach very high values, even to the point of arcing. In addition, the impedance of the primary winding of the current transformer (one turn, in this case) will increase greatly, resulting in a drastic fall-off in power through the system. In this power supply, removing R26 during testing resulted in the output voltage of the power supply dropping from 1,000 volts to less than 200 volts. No attempt was made to measure the voltage appearing across the secondary of T3.

If the current through transformer T2 increases sufficiently, the voltage at the gate of IC U3B pins 8 and 9 will go high enough to force the output on pin 10 low. The low will be gated through diode D51 to U3c pin 1, pulling it low. This will force U3c pin 3 high, and set the U3c-U3d flip-flop to the shutdown state. Potentiometer VR2 is normally adjusted to cause shutdown of the power supply at about 15 amperes peak transformer current.

PROTECTION AGAINST A SHORTED SWITCHING TRANSISTOR

From inspection of the diagram, you can easily see how sample transformer T3 will monitor the current flowing from switching transistors Q1 and Q2 to the switching transformer T2, thereby protecting against overcurrent through the transformer. But what about the case where either Q1 or Q2 fails shorted? Since transformer T3 does not "see" current flowing directly between Q1 and Q2, what will happen if one of them shorts out?

Interestingly enough, it turns out that T3 handles that, too. Here's how it works. Remember capacitor C1? It blocks any DC from getting into the primary winding of T2. Because of the large value (12 uF) of C1, during normal operation C1 never has a chance to charge up very much before the opposite polarity switching pulse arrives and discharges C1. This means that C1 normally has little, if any, DC voltage charge.

Now, suppose that Q1 has failed and become a dead short circuit. This means that +130 volts will be steadily applied to capacitor C1 through now-shorted transistor Q1. Since C1 is now connected to the +130 volt buss for a much longer time than normal due to the short through Q1, capacitor C1 will be able to charge to a higher DC voltage than it is supposed to in normal operation. C1 will continue to accept a DC charge through Q1 until Q2 is turned on by the driver circuit of U1.

As soon as Q2 turns on, there will be a short circuit formed between the +130 and -130 volt buss through transistors Q1 and Q2. At that instant, the side of capacitor C1 which was at +130 volts is suddenly lowered to zero. (+130 volts through shorted transistor Q1 plus the -130 volts through just-turned-on transistor Q2 equals zero volts at capacitor C1.)

C1 immediately starts to fall back to zero volts. Because C1 has been charged to a higher than normal DC voltage by virtue of shorted transistor Q1, the current flowing from C1 and through the primary winding of T2 will be much greater than normal. Transformer T3 will detect the excessive current and cause the overcurrent protection circuit to shut down the power supply.

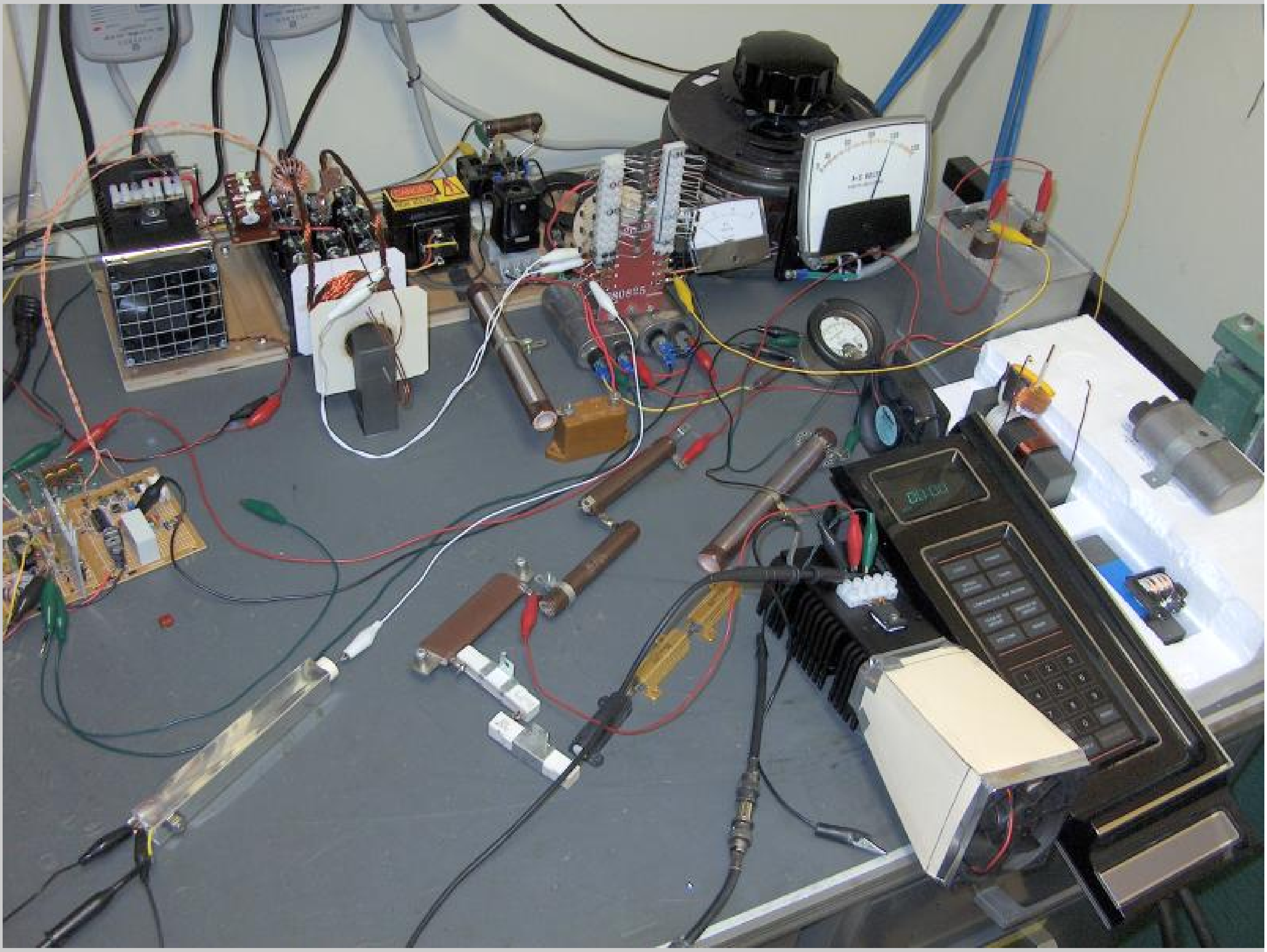
PROTECTION AGAINST EXTERNAL OVERLOADS

Power supply output overcurrent from such things as tube arcs, flashovers and poking your fingers in the PA circuitry with the plate power on are handled by sensing the voltage drop across resistor R1. All of the current from the power supply to the load flows through R1. Although the voltage drop across R1 does affect the output voltage slightly, it is only about 5 volts at 1 ampere load current. The sample voltage from R1 appears across potentiometer VR3, and is filtered by R29 and

C14 to remove high frequency noise. Zener diode ZD3 protects against voltage surges in case of a short circuit across the output of the supply which would cause the voltage across R1 to rise to several hundred volts during the short circuit time.

LOAD STABILITY OF THE POWER SUPPLY

The power supply was tested under load and found to be quite stable with loads ranging from 10 to 100%. To determine the performance of the power supply under transient loads, such as might be encountered during SSB or CW amplifier operation, a series of pulse tests were undertaken.

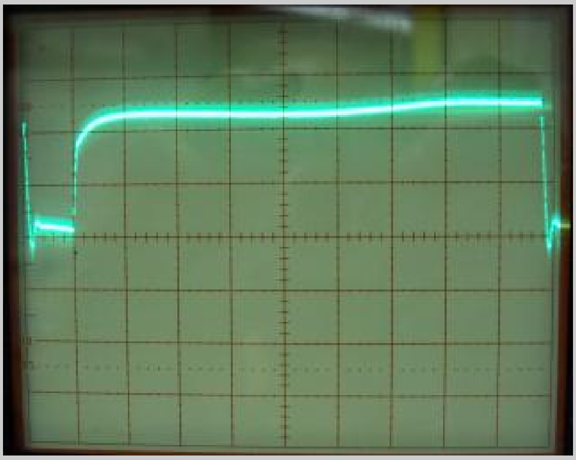


This is the power supply all set up for pulse load testing.

Here you can see the combination of load resistors used for testing. The IGBT transistor which is used to switch the load resistors in and out of the circuit is mounted on the black heat sink with the cardboard fan duct attached to it. Its gate is driven by a function generator. Note the use of a recycled timer panel from an old microwave oven. This makes it very easy to turn the mains power to the switching power supply on for a predetermined length of time for testing. The panel may be moved back a safe distance from the device being tested in case you expect a few parts to explode! The 100:1 high voltage probe is the length of square aluminum tube just to the left of the load resistors.

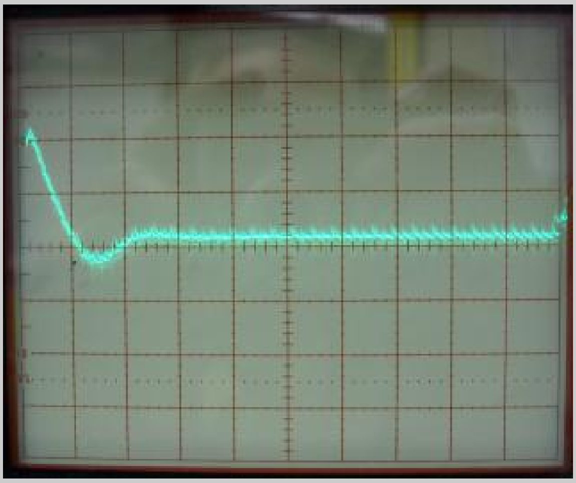
Using a high voltage IGBT of the same type as is used for the switching transistors, and using a series string of load resistors the test setup was configured so that by gating the IGBT on and off, the current drawn from the power supply could be instantly switched between 175 and 750 mA and then just as quickly switched back from 750 to 175 mA. Using a square wave, the IGBT was gated at various frequencies and for varying pulse widths from 1% to 99% on- to-off ratios. In all cases it was found that the supply operated consistently well, with no evidence of instability or erratic operation.

The pictures shown here were taken with a 100:1 shielded resistive voltage divider network connected across the +1,500 volt output of the power supply. The scale of these pictures is 1 volt per major vertical division.



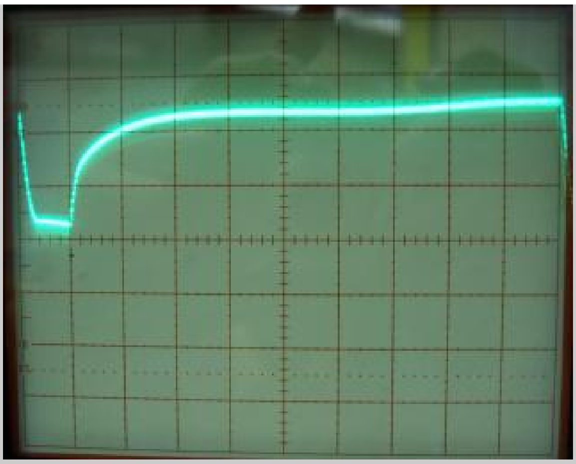
Picture 1) The load pulse is 10 milliseconds per major horizontal division, high voltage filter capacitor is 2 uF.

The output voltage drops by about 2 volts with the application of the load to the supply. It promptly recovers and stabilizes at about than 2 volts below the initial value. At the end of the load pulse, the output voltage rapidly recovers to the previous level. Note the lack of voltage overshoot when the load is removed. The overall shape of the voltage drop and recovery remained the same, regardless of the width of the load pulse.



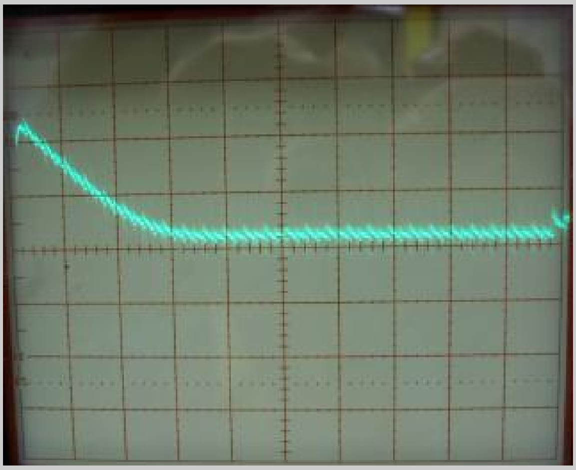
Picture 2) The load pulse is 1 millisecond per major horizontal division, high voltage filter capacitor is 2 uF.

This is the same load pulse as was seen in picture 1, but the horizontal scale has been expanded 10X . This shows that within about 2.2 milliseconds the power supply output voltage has stabilized, with only a very slight voltage undershoot when the load is applied. This appears to be a critically damped wave, which indicates that we should use a filter capacity value of between 2 and 4 uF for good filtering and to limit the amount of stored energy in the filter capacitor in case of an arc in one of the final amplifier tubes.



Picture 3) The load pulse is 10 milliseconds per major horizontal division, high voltage filter capacitor is 6 uF.

Here, we have increased the high voltage filter capacitor from 2 uF to 6 uF. The first thing we notice is that the slight voltage undershoot is gone. It also takes a little more time for the voltage to fall to the new, slightly lower value under load. We also see that the voltage recovery time when the load is removed is also increased. It appears that 6 uF is slightly more filtering capacitance than is needed. The waveform is slightly overdamped. There is also more of a "bobble" in the voltage recovery after the load pulse is removed. However, it will work quite well as a filter capacitor in the power supply. One drawback of the additional filter capacity is that with the extra energy stored in the 6 uF filter capacitor, there is more energy available to cause damage should there happen to be an arc in one of the amplifier tubes.



Picture 4) The load pulse is 1 millisecond per major horizontal division, high voltage filter capacitor is 6 uF.

When we look at the load pulse at the same scale as picture 2, we can easily see the absence of the voltage undershoot.

Note that it also requires about 3 milliseconds for the voltage to reach its lowest value when the load is applied. This is because of the additional damping provided by the added filter capacity.

CLOSING COMMENTS

It should be mentioned here that the photographs shown here are of the prototype unit. Most of the components will be mounted inside the Heath Warrior amplifier cabinet in place of the original and now defunct power supply. The parts layout on the perf board as seen here is not to be taken as "the last word" in assembly or parts placement. As long as you keep the component leads short and observe good engineering methods, you should have no problems in making this, or a similar switching supply function properly.

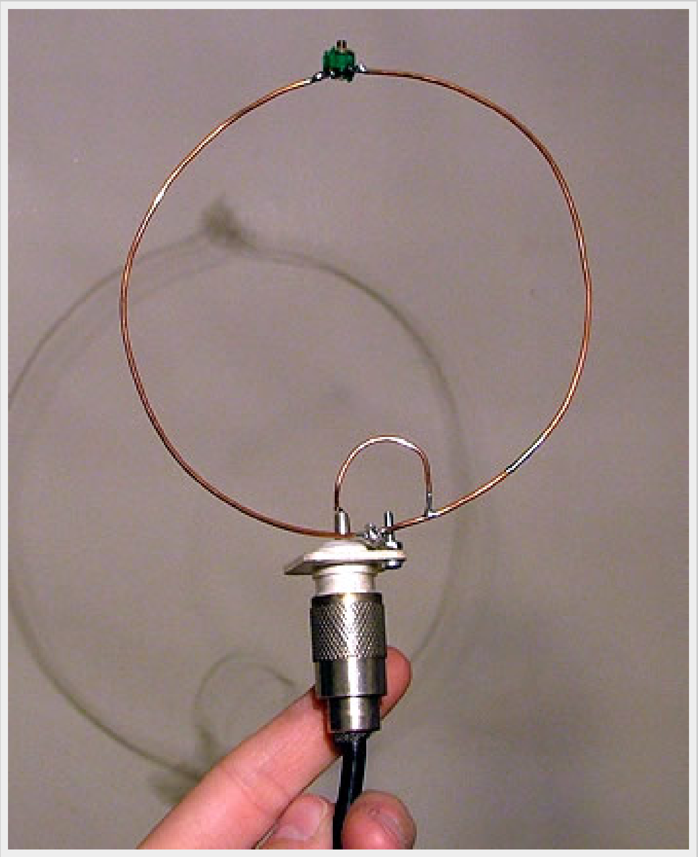
I hope this article proves useful to you. Please let me know if you have any suggestions or comments about this article.

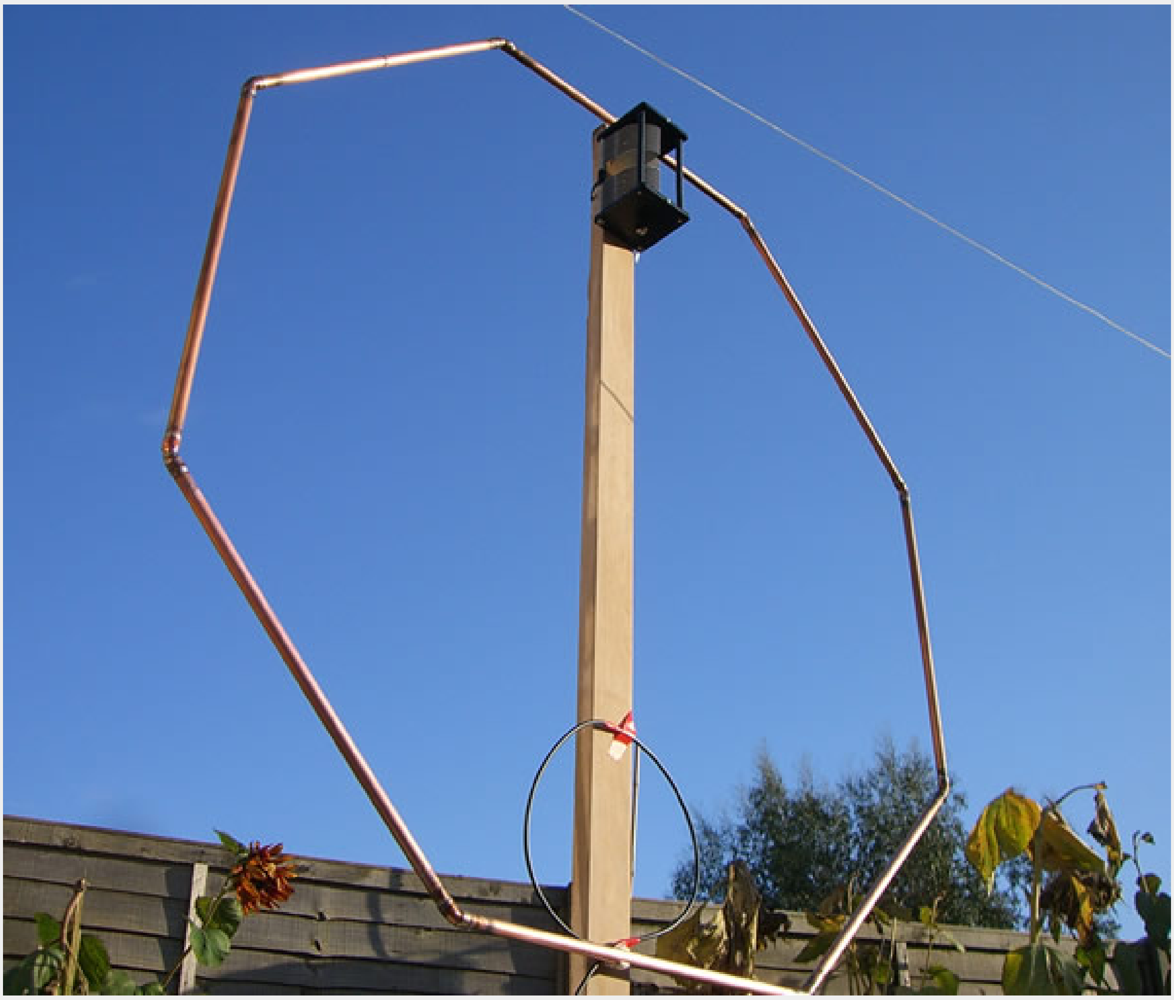
73,

W5JGV

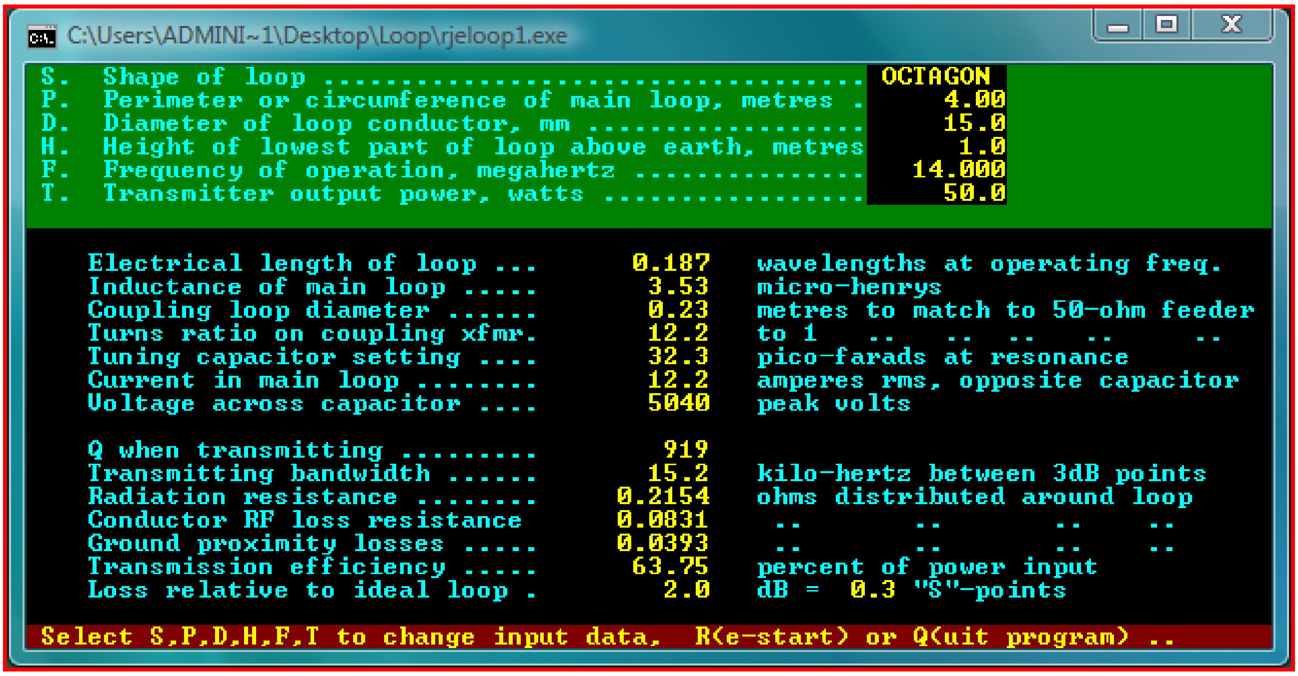
[Home]

Magnetic Loop Antennas





Magnetic loop design software


C:\Users\ADMINI~1\Desktop\Loop\rjeloop1.exe
S. Shape of loop .... OCTAGON
P. Perimeter or circumference of main loop, metres . 4.00
D. Diameter of loop conductor, mm 15.0
H. Height of lowest part of loop above earth, metres 1.0
F. Frequency of operation, megahertz 14.000
T. Transmitter output power, watts 50.0
Electrical length of loop ... 0.187 wavelengths at operating freq.
Inductance of main loop ..... 3.53 micro-henrys
Coupling loop diameter ...... 0.23 metres to match to 50-ohm feeder
Turns ratio on coupling xfmr. 12.2 to 1 .. ..
Tuning capacitor setting .... 32.3 pico-farads at resonance
Current in main loop .... 12.2 amperes rms, opposite capacitor
Voltage across capacitor .... 5040 peak volts
Q when transmitting 919
Transmitting bandwidth ...... 15.2 kilo-hertz between 3dB points
Radiation resistance .... 0.2154 ohms distributed around loop
Conductor RF loss resistance 0.0831 .. ..
Ground proximity losses ..... 0.0393 .. ..
Transmission efficiency ..... 63.75 percent of power input
Loss relative to ideal loop . 2.0 dB = 0.3 "S"-points
Select S,P,D,H,F,T to change input data, R(e-start) or Q(uit program) ..

The original antenna was designed as a moderately short antenna for the 10 meter band.

I originally wanted an antenna that would not hit everything overhead while driving, since it was to be installed on a van. I came up with an antenna that extended only 1.65 meters or about 5 feet 4 inches above the top of the vehicle. It had a calculated efficiency of 42% when compared to a half-wave dipole. It was my hope to be able to install a series of different loading coils to be able to operate on the other HF bands. However, calculations

indicated that the antennas was simply too short to work well as the frequency was lowered. Something better was needed.

The Evolution of the Antenna Design

My first thought was to increase the length of the antenna below the loading coil. My reasoning was that since that portion of the antenna carries the highest RF current, then adding more length there would increase the radiation efficiency of the antenna more than would adding the same length to the antenna above the coil. Unfortunately, since the antenna is mounted on top of a van which is a rather high vehicle, that would place the coil at a dangerous height with regard to tree branches and the like. Since the loading coils were going to be rather heavy due to their sturdy construction, placing a heavy coil high up on a flexible support did not seem like a good idea. I decided to investigate what increasing the length of the upper portion of the antenna would do to the radiation efficiency.

It quickly became apparent that very good results could be obtained by increasing the top whip length. As it turned out, this was due to two factors. First, the antenna was center loaded, and second, increasing the top whip length greatly reduced the coil losses due to the smaller number of turns required. This also meant that I could use larger wire for the coils, which further reduced the losses. It was almost like getting something for nothing!

Since I had once a standard CB-length whip plus the magnetic mount and base spring installed on the van, I knew that a total height of 3 meters was workable, even though it did hit quite a number of overhead obstructions. I ran calculations to determine how it would work. The results were very encouraging, and I promptly set out to build the antenna. I still had the CB whip, and figured that I could simply cut the top end off of it to get the total length of 3 meters for the completed antenna.

While laying out all the parts on the ground to see how they would fit together, I looked at the CB whip and realized that I would only have to cut off about 17 inches. That seemed like a waste, and I really hated to cut that small amount off of a perfectly good antenna.

Just for fun, I decided to repeat the calculations to see what would happen to the gain if I left the extra 17 inches on the antenna. I was surprised to find that the antenna efficiency increased between 19 and 31 percent, depending on frequency. The trade off, of course, was that I knew the antenna was going to hit a lot more objects overhead than if I trimmed the 17 inches off of it. As a test, I assembled the antenna full length and drove around with it for a few weeks to determined how much of a problem it would be. I decided that I could live with it, as a necessary price for the increased signal strength.

This table shows the results of the calculations. Notice the large jump in gain between the original short antenna and the 3 meter antenna. Longer IS better! <G>

Computed Radiation Efficiency of Center Loaded Mobile Antenna vs. 1/2 wave Dipole Antenna

TEST FREQUENCY, MHz	Original 1.65 Meter Antenna	Proposed 3.0 Meter Antenna	Actual 3.42 Meter Antenna	% GAIN INCREASE 1.65 > 3.0 Meters	% GAIN INCREASE 3.0 > 3.42 Meters
1.95	0.09	0.3	0.4	333	31
3.9	0.5	1.5	1.9	300	26
7.3	2.0	5.5	6.9	275	22
10	3.9	10	12.4	256	23

14.2	7.6	18.8	22.8	247	22
18.15	12	27.7	33	231	19
21.2	15.7	34.6	40.6	220	19
24.9	20.3	40.6	40.6	200	0
28.4	24.7	40.6	40.6	164	0

Construction Details

I was able to make use of the basic antenna design and most of the parts when constructed the final antenna. I'll show you in the following pictures how I did it. This is a very easy antenna to build, and you can do it with some simple tools and parts from the local home improvement or hardware store.

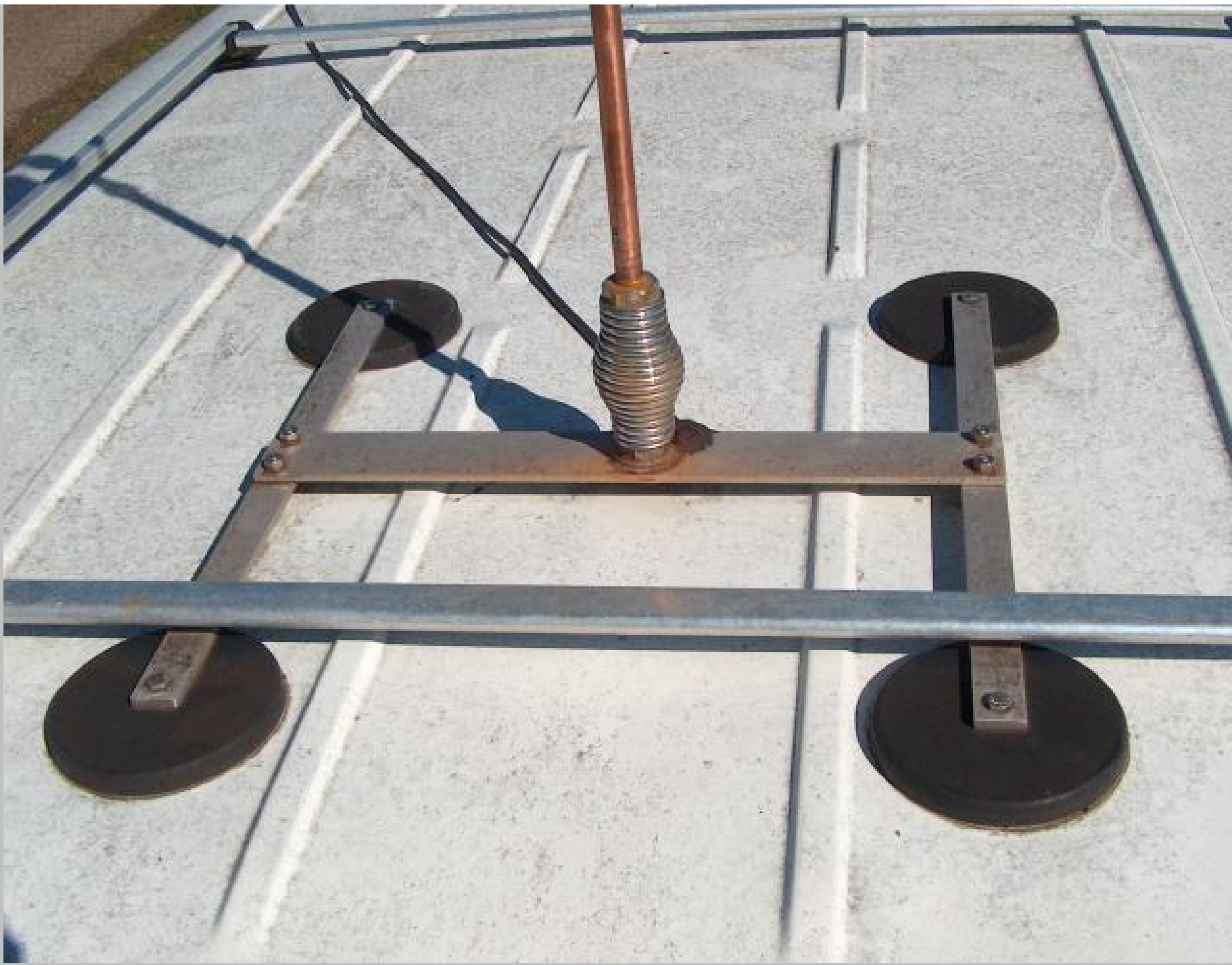
When I made the 10 meter coil for the first 1.65 meter long antenna, I used 1/4" OD copper tube for the coil. I inserted the ends of the coil into a short length of 3/8" OD copper tube and then flattened the ends of the tube. I then drilled a 1/4" diameter hole through the flattened ends so they could be attached to the antenna posts. This

coil should have had one more turn on it. That way, the turns would have been spaced a bit further apart. This would have lessened the coil losses somewhat. However, the calculated loss in power was not enough to worry about, so I never bothered to make a new coil for the antenna.

See that length of clear plastic between the ends of the coil? When using a self-supporting coil like this one, you MUST use an insulating brace like the plastic strip shown here or the white insulator between the two antenna sections will fracture when you hit a big tree branch with the antenna!

This is a close-up picture of one of the ends of the loading coil.

You can see the coil tube inside the larger flattened copper tube. The larger tube added structural strength to the ends of the coil and provided a larger area for drilling the mounting bolt holes through the coil ends.



A big antenna needs a serious mag-mount!

I purchased this magnetic mount for my mobile antenna years ago over the Internet - I don't remember where I got it - but it holds to the roof like a barnacle on a ships' hull. You can fold the antenna over until it touches the roof of the van and the mag-mount stays put. It requires two hands and a short pry-bar to get it loose.

See all that rust on the horizontal bar? That's from a cheap steel quick disconnect I used for several years. It finally rusted to then point that it made intermittent contact and I decided to get rid of it. So far, I have not found anything strong enough to replace it. I have broken two fairly heavy brass quick disconnects so far. So, for now, I just either tie the antenna down to the roof of the van or unscrew it when I have to go into a low garage. Needless to say, I strongly favor outside parking spaces!

This picture was taken before I installed the quick disconnect. It shows the lower end of the bottom section of the antenna. The antenna mast sections are constructed from hard wall copper pipe, 1/2" in diameter. A brass plug with a 3/8" x 24 threaded hole was pressed into the end of the copper pipe and hard-soldered into place. To hold the plug in place during the soldering process, I rolled several grooves around the outside of the copper pipe as seen here. I was careful not to roll them too deeply and weaken the pipe.

A small "weep hole" is drilled through the pipe wall just above the upper end of the brass plug that was soldered into the pipe. The hole allows water to drain out of the antenna and not sit inside and corrode the mounting bolt. Water WILL get into the antenna - you can't prevent it - so you might as well make provisions to allow the water to drain out.

To hold the antenna to the base spring, I used a length of threaded steel rod cut from a stainless steel bolt. After making sure that the threaded rod was the the correct length and that everything fit properly, I removed the mounting bolt from the base of the antenna and the base spring and used thread locking compound (OK, I used Super Glue, if you must know) to retain the bolt in the base of the antenna. That way I would not misplace the bolt when I had to remove the antenna from the base spring.

The Center Insulator and Coil Mounts.

The lower section of the antenna is a 1/2" diameter copper pipe about 60 cm (24 inches) long that extends upward to the lower coil support.

The support itself is made from a 1/2" sweat "T" fitting, a 2" length of 1/2" copper pipe and a 1/2" sweat cap.

The bolts holding the coil in place are 1/4" diameter x 1-1/2" long stainless steel bolts. A 1/4" hole is drilled through the center of each pipe cap before soldering it in place, and the bolts are temporarily held in place by gently tightening the nut visible in this picture.

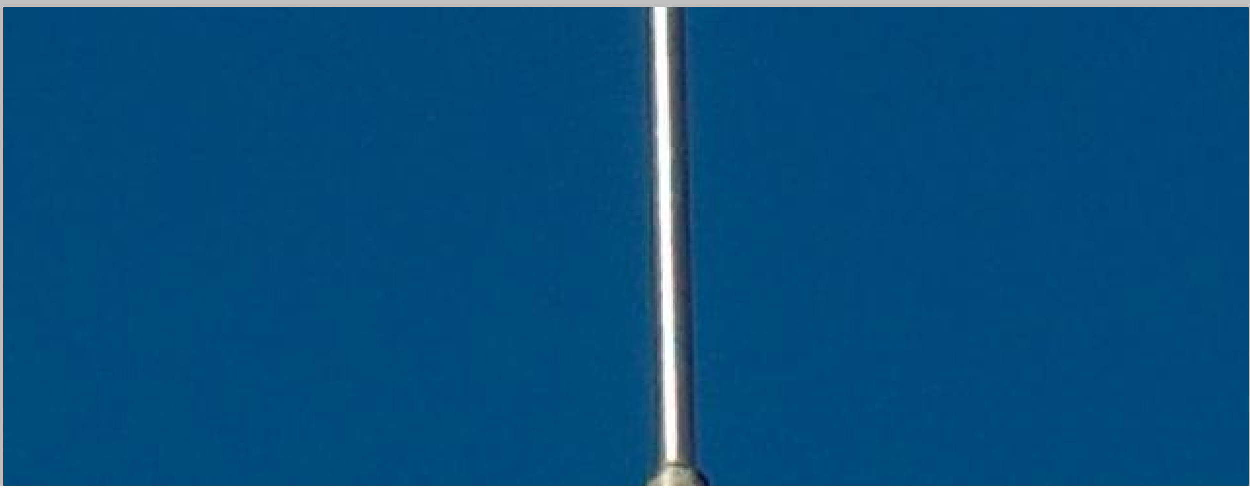
The plastic center insulator is a 1/2" female-female threaded PVC coupler.

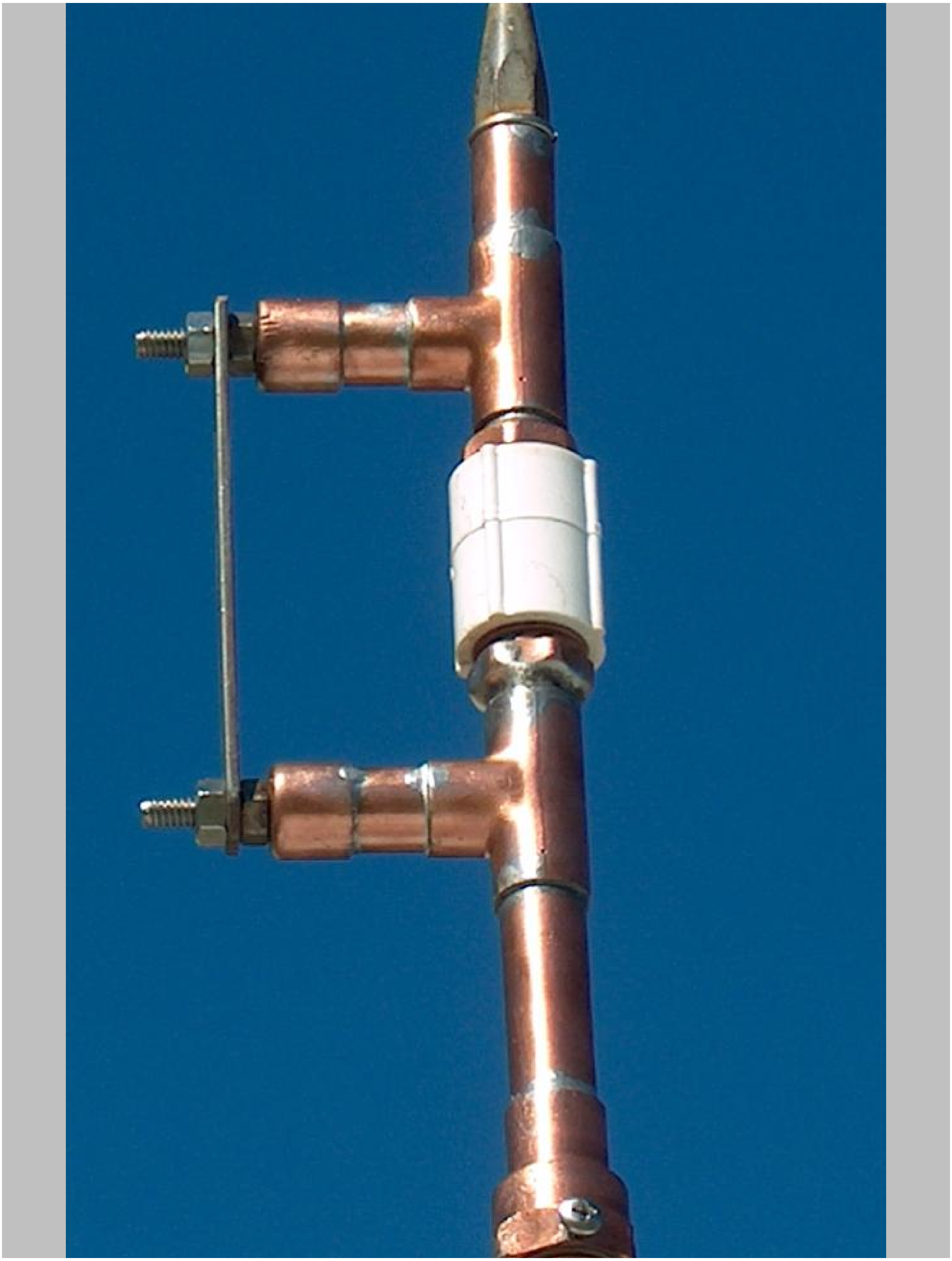
Each end of the antenna sections that thread into this coupler has copper adapters that go from 1/2" OD copper pipe to 1/2" iron pipe. These fittings have a male thread on them so they will screw into the plastic coupler which then becomes the antenna center insulator.

Using plumbers hard solder (not rosin core radio solder) and the proper cleaning flux, the copper components are soldered together.

Next, the interior of the copper sections is thoroughly washed with clean water to remove any soldering flux residue and then placed in the sun or some other warm place to dry.

When everything is dry, the nuts on the coil mounting bolts are firmly tightened, and the sections may be screwed into the center insulator.





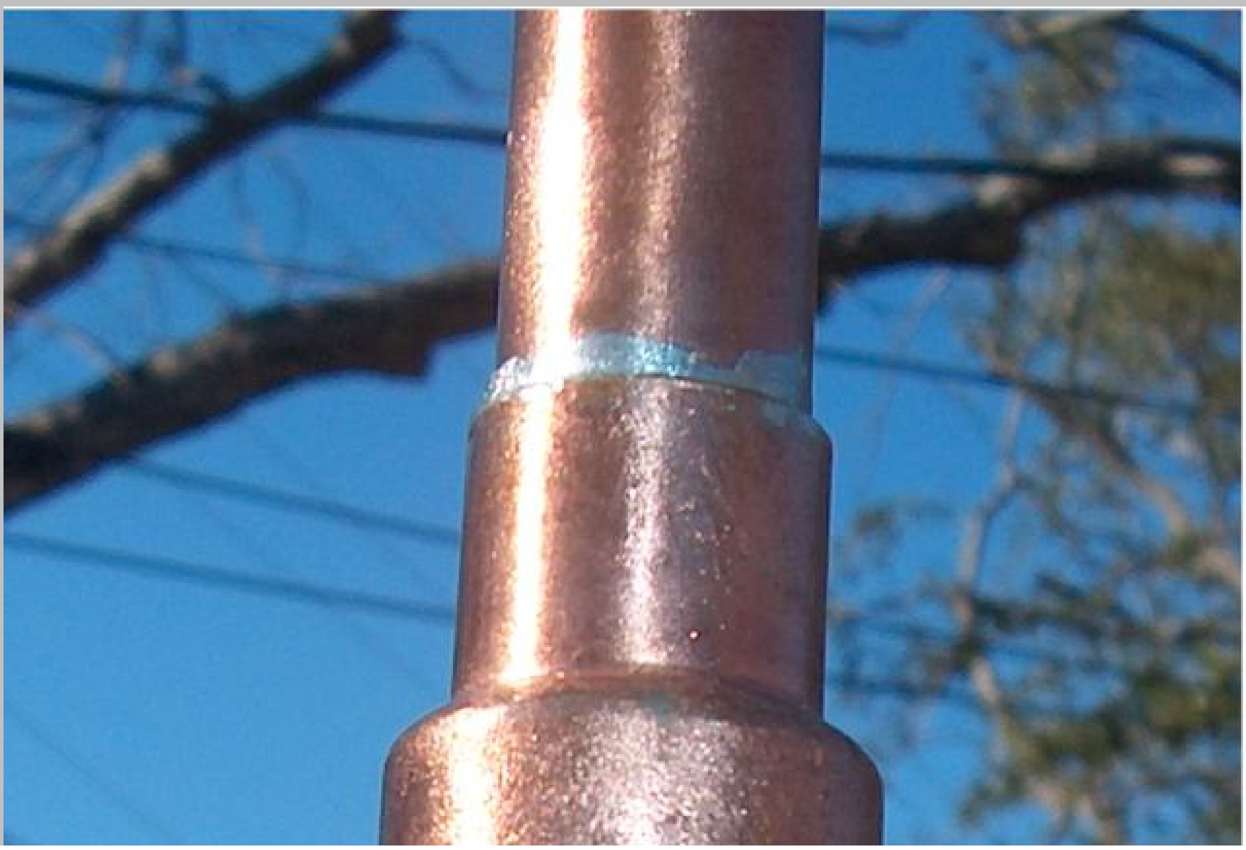
The coil support posts shown with the 10 - 12 - 15 meter shunt strap in place.

Note that with this shunt strap in place, the plastic strengthening strip is not needed. This is because the shunt strap is made from a length of heavy silver-plated copper stock.

The top support for the loading coil is fabricated in the same manner as the bottom support.

To hold the top whip, a 2" long length of 1/2" OD copper pipe is soldered into the "T" fitting. Another female threaded brass plug is inserted into the top end of the 2" long pipe section and soldered in place.

Hey! What's that extra set of pipe fittings doing, and why are they there? (Keep reading for the answer!)



A (very) close up photo of those extra pipe fittings.

I always had a problem getting the antenna loading coil lined up "just so" on the mount. When you screw the antenna into the mount, you never know where the loading coil will be pointing when the mounting screw is tight. With coaxial mounted loading coils, this is not a problem, but this antenna has the loading coil mounted off-center from the mast. Provision needs to be made to adjust the coil position. How come?

Well, the loading coil must always "trail" the antenna mast; that is, the coil must be directly behind the antenna mast when the vehicle is moving. The reason is rather obvious - after you hit the first big low-hanging tree branch! If the coil happens to be in front of the antenna mast, the coil may become snagged on the tree branch and instantly becomes part of the local roadside litter. When the coil is mounted behind the mast, the mast simply slides harmlessly beneath the tree branch, the coil does not get hit, and all is well.

In order to accomplish this alignment without resorting to the use of shim stock, various thicknesses of washers, and all sorts of other chicanery, I decided I had to have a way to be able to rotate the coil around the mast in some way. Since everything was soldered together, I came up with the idea of using a pair of threaded mating fittings that I could simply twist to get the alignment exactly correct. I drilled and threaded a pair of holes

through the outside (female) fitting so I could use a pair of stainless steel screws to lock the fittings in place after after the adjustment was complete.

The 40 Meter loading coil in place on the antenna.

Notice the stainless steel nut at the bottom of the coil. This nit, and another one at the top of the coil holds the coil on the antenna. Changing coils is easy. Simply remove the nuts at the top and bottom of the coil, swap coils, and replace the nuts. Tighten firmly - but not excessively - and the PVC plastic acts as a lock nut to keep the coil in place. Still, it's a good idea to carry a few spare nuts in the vehicle in case you drop one while changing coils.

The complete Coil Set for the antenna.

From left to right -

Top Row: coil form made from 2" OD schedule 40 PVC pipe; old self-supporting 10-meter coil made from 1/4" copper tubing; plastic support spacer, used with self-supporting coils; copper shunt ring, used to tune loading coils.

Bottom Row: loading coils for 160-meters, 75-meters, 40-meters, 20-meters, and 17-meters.

The 160 and 75-meter coils are wound using #14 AWG Nylon insulated wire; all the rest of the coils are wound with #10 AWG THHN insulated wire. Note that no terminals are used on the coils - the wire ends are simply wrapped around the mounting bolts. When the coil is attached to the antenna, the wire loops are pressed against the copper coil mounts to make the electrical connection by the coil form when you tighten the 1/4" nuts from the inside of the coil form.

General Coil Construction

The coil form is made from a length of 2" OD PVC pipe. I cut each coil form about 3/4" longer on each end than the spacing between the mounting bolts. NOTE: Make sure that each coil form fits easily over the mounting bolts before winding on the wire or you'll have problems changing coils.

After winding the wire on each coil, an application of epoxy adhesive (J-B Kwik) was used to keep the coil turns in place. A coat of black spray paint was applied for appearance and to make the white plastic coil form less noticeable. NOTE: Apply the epoxy AFTER you have adjusted the coil to resonance.

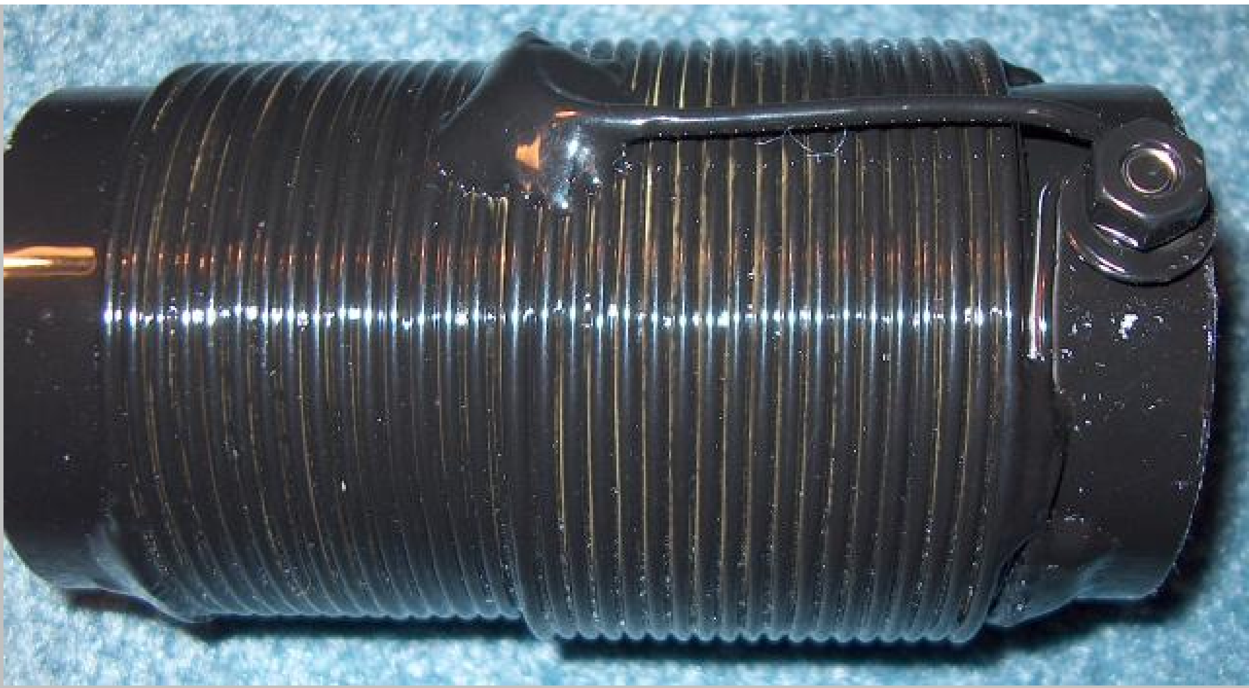
If you just wind the wire on the coil forms directly, this will result in the coil "springing back" and becoming loose on the form when you release the wire after winding it. I wound several extra turns on each coil as I wound it on the form, then removed the coil from the coil form and then squeezed it down around a slightly smaller form (actually a spray can of insect repellent.) I then removed the now slightly smaller diameter coil and gently screwed it onto the coil form, where it remained tight enough to stay in place properly.

The 75-Meter coil

The calculations indicated that I would need to use #22 AWG wire to get enough turns on the coil in the space I had available. The losses would have been quite high, if I used that small size wire. So, this coil is wound with #14 AWG wire. Since using larger wire would not allow as many turns in the same length, I could either use a larger diameter form (too much wind resistance and negative "eye appeal",) or a longer form, continuing the extra turns below the lower mounting bolt (wind resistance, and higher RF losses.) Something better was needed.

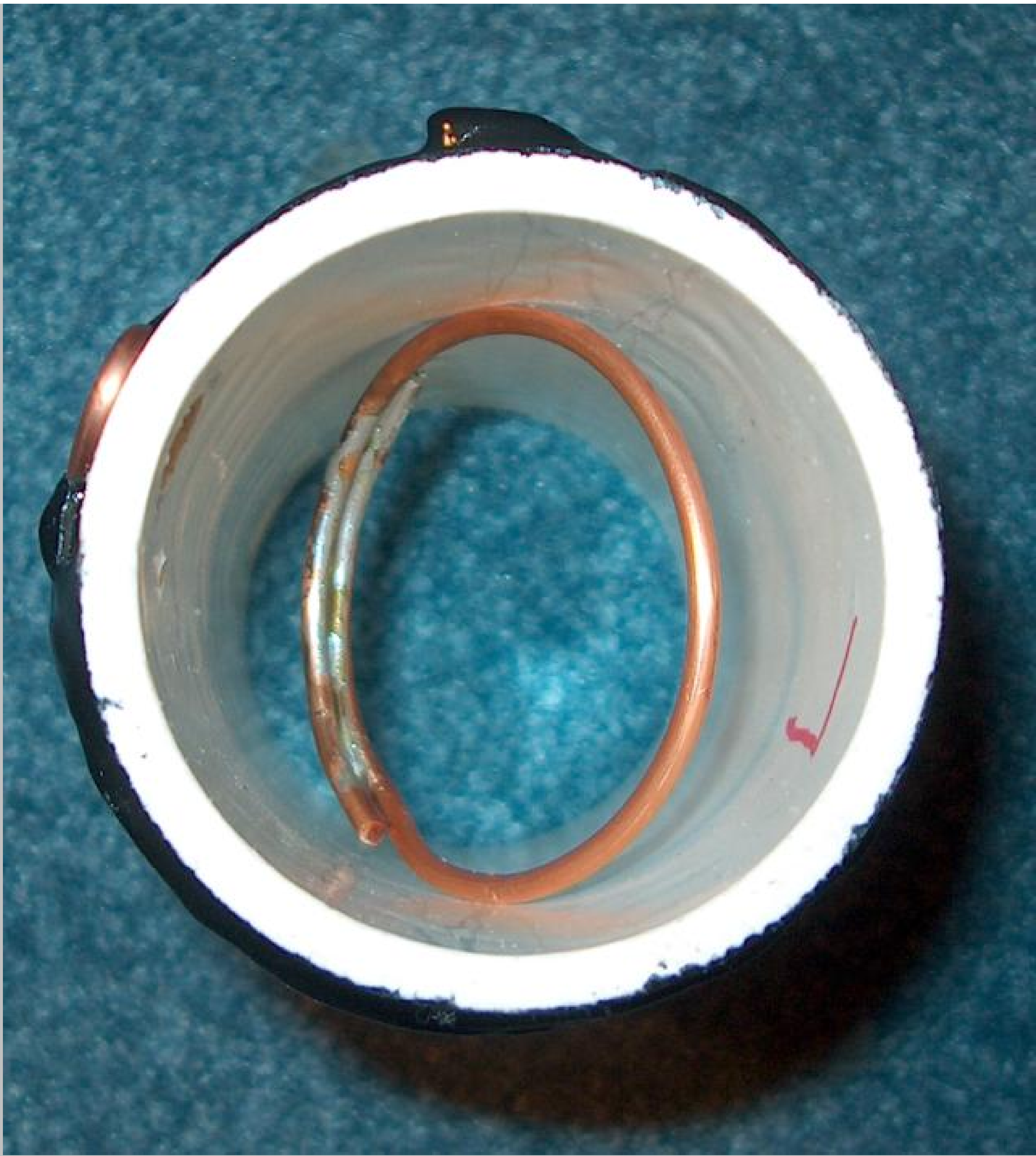
Remembering my switching power supply transformer winding experience, I decided to try winding the loading coil for the antenna in the same manner, that is, complete the first layer of the winding in the usual manner, then "jump" the winding end back up towards the start of the first layer and then continue the second layer of the winding towards the end of the first layer of the winding. This is sometimes referred to as a "Z" winding.

You can see the black painted bolt in the right of the photo that holds the end of the first layer of the winding. From that bolt, the wire that begins the second layer "jumps" back to the left of the second layer of the winding. The end of the second layer is brought out to one of the mounting bolt holes. You can see the epoxy that holds the windings in place.



The 160-Meter Coil

Wound in the same manner as the 75-meter coil, the 160-meter coil required only 60% of the number of turns as would be needed if the windings were in a single layer. The trade off is that there are several stray resonances of the antenna system using this coil, but none of them cause any problems with normal operation. Since less wire is used in this coil than would be used in a single layer coil, the copper losses are less, but the dielectric losses are slightly higher due to the overlapped windings. However, the use of the "Z" winding method minimizes the dielectric losses as much as possible. The measured Rac loss of this coil is less than the originally calculated coil using #22 AWG wire.



Tuning Ring in place inside the 40-Meter Coil

As it turned out, I didn't need to use it, but I found that I could insert a shorted copper ring inside the coil and adjust the antenna tuning plus or minus a turn or so on each coil. I also tried using various types of ferrite and iron tuning slugs, but found that the copper ring produced less extra loss in the coil than did the ferrite core. When the ring is placed parallel to the turns on the coil, it acts like a shorted turn and reduces the inductance of the coil. The ring fits in place by friction, and after adjusting it, it may be permanently attached with some epoxy. Further minor adjustments may then be made by bending the ring slightly.

ADDITIONAL LOADING COIL DATA

(This loading coil data was added on 24 July 2010)

Since this article went on-line, I have received quite a few questions about the exact construction of the loading coils. Although it is possible for a careful observer to look at the photos posted on this page and deduce the construction of the coils, it is probably a good idea for me to post a more complete description of the construction of the coils so the reader can more easily build them.

In the chart below, all the coils are wound on lengths of Schedule 40 white PVC pipe. The actual end-to-end length of the coil windings is shown in the chart. Due to the thickness of the insulation on the THHN wire, the actual diameter of the finished coil will be close to 2.5 inches. The inductance values are what I measured on my completed loading coils.

FREQUENCY BAND	INDUCTANCE	WIRE GAUGE	NUMBER OF TURNS	COIL LENGTH	COIL DIAMETER	COIL FORM
18 MHz	1.5 uHy	# 10 THHN	5	3.5 Inches	2.5 Inches	2" PVC sch 40 Pipe
14 MHz	3.8 uHy	# 10 THHN	9	3.5 Inches	2.5 Inches	2" PVC sch 40 Pipe
7 MHz	16.5 uHy	# 10 THHN	22	3.5 Inches	2.5 Inches	2" PVC sch 40 Pipe
4 MHz	55 uHy	# 14 THHN	Layer 1 = 34, Layer 2 = 6, overlaps layer 1	3.75 Inches	2.5 Inches	2" PVC sch 40 Pipe
2 MHz	100 uHy	# 14 THHN	Layer 1 = 34, Layer 2 = 20, overlaps layer 1	3.75 Inches	2.5 Inches	2" PVC sch 40 Pipe

Note that the coils for 160 and 75 meters have overlapping coil windings. This can be avoided by using smaller diameter wire or using a longer length coil form. Depending on where you place the top layer of wire on the first layer (near one end or near the center of the first layer of wire) the inductance of the coil will vary somewhat, and you may need to adjust the number of turns on the coil. Tuning on the lower frequency bands will be more critical, so you should expect to do some tuning as needed.

Please note that these exact coils may NOT work for you in your particular situation. Factors such as whip length, height above ground, size of the vehicle, etc., will require tuning the antenna, either by tweaking the number of turns on the coils or adjusting the length of the antenna's top whip slightly. In my case, "close enough" was good enough, because I planned to use an antenna tuner in my mobile station. In any case, the dimensions given in the chart above should get you "in the ball park", as it were.

Tuning the Antenna

A center loaded vertical antenna will not present a pure resistive load at the base of the antenna. Usually, a matching network is added at the bottom of the antenna to cancel the reactance and transform the lower than 50 Ohm feedpoint resistance to something close to 50 Ohms. Since this antenna was designed to operate over several HF bands, a single matching network is impractical. Instead, I chose to connect the antenna through a length of low-loss coaxial cable to an automatic antenna tuner (ATU) inside the vehicle within reach of the operator and out of the weather.

To make the best use of the antenna with this set-up, the loading coils for the antenna should be tuned to resonance at the high end of each band. The antenna will then look electrically "short" to the tuner, which will then be able to tune the antenna to the desired operating frequency. If the loading coil in the antenna is tuned to a frequency below the top of the band, then operation above that critical frequency will cause the antenna to look

ON6MU

RF Power meter / dummy load

By Guy, de ON6MU

rev1.2

About the power meter / dummy load

A 50 Ohm dummyload is an essential part for any radioamateur as is a powermeter. The prices of such relative simple equipment is expensive, but not for us handy Hams HI. All you need is a metal box (or plastic box painted inside with graphite or other conducting/RF-shielding capable material), a few resistors and basic components (which can be salvaged from old radio's, switching power supplies etc..) and a analog meter. I used a Radio-shack meter, but any (sensitive) meter can be used. It's all a matter of calibrating your meter correctly, which is easy if you can lend a good commercial RF power meter.

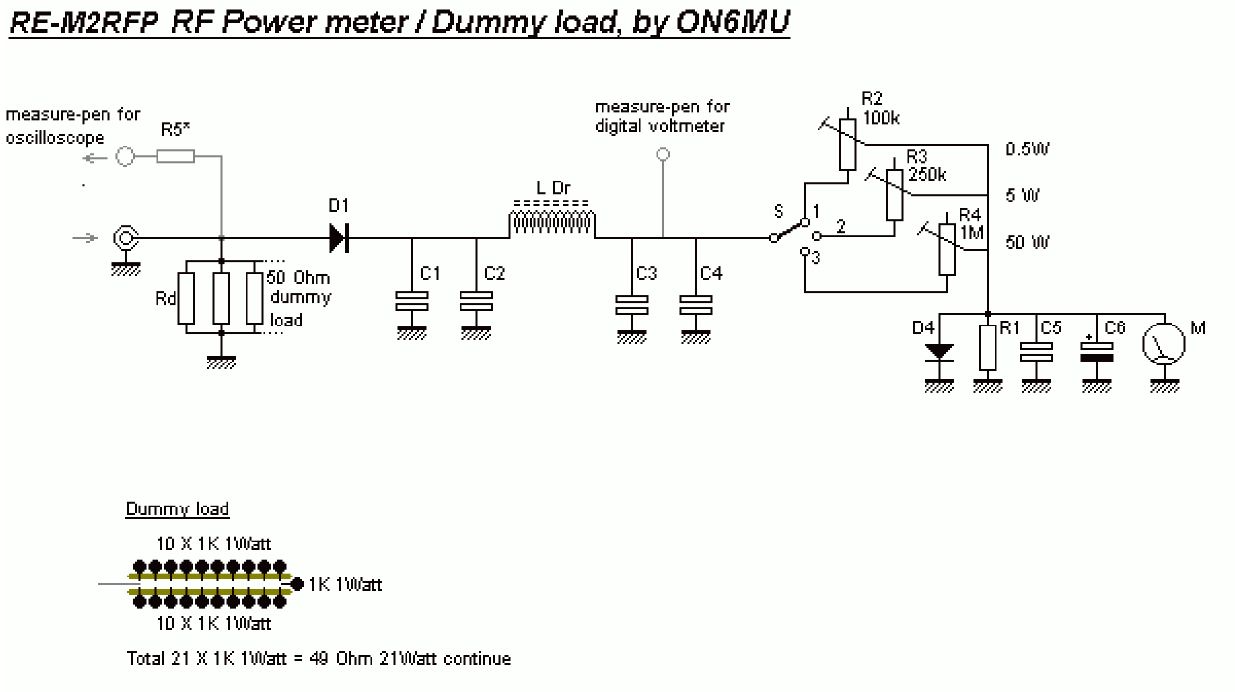
This RF-power meter combined with build-in dummy load is made to measure power levels starting from a few milliwatt up to 50 watts (or more if suitable components are used and an avalanche sinterglass diode). IT has 3 scale readings: 0.5 watt, 5 watt and 50 watts. Again, you can extend the scales easily. The power meter is ideal for measuring QRP levels and by adding a connector you'll have an easy oscilloscope measuring point.

In short, an easy and cheap project to build yourself. Even a beginner in HAM homebrewing can make his own fair (if not better then most you buy in the shop) power meter!

Calibration

Is done with a good (commercial or already calibrated) SWR/RF power meter capable of measuring HF power levels from 5 (or less) to 50 watts and has a frequency range that covers the entire HF-band. You also need a transceiver which you set in series with the meter: TRX -> COMMERCIAL RF METER -> ON6MU RF METER. Set all potentiometers (R2,R3,R4) to maximum resistance. Choose one of the scales (0.5, 5 or 50 watts) to start with. Other power levels/scales with the same step (X1 X10 X100) will have the same indication multiplied. So if you choose scale 2 being 5 watt and calibrate at least 5 power levels of your transceiver it should be ok for the other scale selections. Set R3 for full scale at 5 watt and work your way down. One calibration for all power level settings respectively is sufficient.

Schematic fig1



Parts list

- alu box (or plastic box painted inside with graphite) of 100mm X 100mm X 50mm
- 1 female PL 259 chassis (SO239)
- 1 connector to be used as oscilloscope measuring point
- Analog Meter (as sensitive as possible and calibrate the scale with a good powermeter)
- C1,C3 = 330pF
- C2,C4 = 47nF high quality
- C5 = 100nF
- C6 = 10uF/6v tantal
- D1,D2 = BYW54...BYW56 (up to 500watt measurements) rev1.2. I used a BYW55 controled avalance rectifier
  = or 1N1448 if you do not need to measure more than 10 watt max
- D4 = 1N1004 (protects the meter for voltages higher then 0.6 volts)
- S1 = 3 pos. switch (or more if you want more power scales)
- L Dr = 500uH or 1M Ohm carbon resistor 1 watt covered with 0,2mm Cul 3 times (or more) turned over the length of the resistor
- R1 = 18k
- R2 = 100k variable resistor
- R3 = 250k variable resistor
- R4 = 1M variable resistor

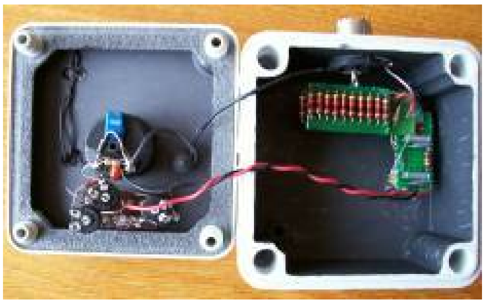
- R5 = 47 (optional; if you add a connector to be used for measuring the RF with an oscilloscope)
- Rd = 50 Ohm Dummy load of at least 20 watt (see text)*

Specifications

- precision power meter capable of measuring power scales of 500mW...100W+ (depending on the dummy load)
- frequency range: entire HF band 1Mc...50Mc
- switchable scale ranges (in this schematic 0.5W, 5W, 50Watts...)
- oscilloscope measuring point
- can be used as dummy load also HI

Note rev1.2*: sometimes the diodes broke when measuring 50watts. To measure power levels up to 100 watts or more a better diode (BYW55) has been used that is suitable for high voltages (Standard Avalanche Sinterglass Diode).

Inside the powermeter



Dummy load

Is build out of 21 carbon resistors (or non inductive metalfilm) of 1K and 1Watt all parallel. I used two 15mm X 50mm print boards and soldered two times 10 resistors on each side. Solder the two parts on top of each other and solder the 21th 1K resistor where the two parts come together. See fig1 and 2. Do not use inductive type of resistors! Always use carbon based resistors or non inductive metalfilm ones. This dummy load is able to dissipate 21 watts continues and no problem to handle a 10 second peek of 50 watts. Long enough to measure the power. Be sure not to transmit high power > 21 watt for a long time as this will burn out your dummy load! IF you need the dummy load to handle more power then you could use 45 2k2 1 watt resistors which doubles the amount of power (and peek power). Of course you can use 1 k resistors of a higher power rating as long as they are non-inductive resistors.

fig.2.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Modifying Conifer Antennas for Wireless Networking
part 1
(first published May 2002, revised June 2002)

This page details a method for constructing a new dipole for a Conifer dish, resulting in improved performance over the more common dipole modification.

Contents:
part 1: Conifer Antennas | Background | Parts Required
part 2: Antenna Disassembly | Dipole Construction
part 3: Reassembly | Testing | References

Conifer (ex Galaxy) Antennas
The antennas we're using are made by Conifer (now known by the name of their parent company, Andrew Corporation), and were used in Australia by a pay-tv company called Galaxy.
Galaxy went out of business several years ago, so there are a lot of un-used Conifer antennas on people's roofs in Australia.

The most common Conifer antenna used by Galaxy is the 18dBi grid, while the 24dBi grid is a little less common. Note that both the 18dBi and 24dBi grids use an identical feedhorn, so this page is applicable for both.

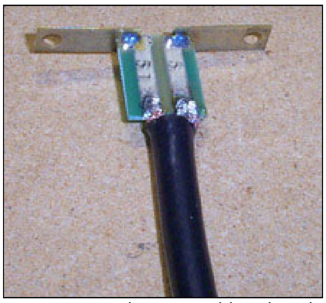
18dBi and 24dBi ex-Galaxy antennas made by Conifer, with a 30cm ruler (bottom right) for scale

However, the Conifer antennas used by Galaxy were designed to operate at a different frequency than wireless networking, and have a down-convertor integrated in the feedhorn.

They need to be modified before they can be used for 802.11b wireless networking, and this page describes one way to modify them, achieving very good results.

an 18dBi Conifer (as installed by Galaxy)

Background
Numerous people have posted guides on modifying Conifer antennas (ex-Galaxy) for use with wireless networking. Most of these guides show how to disasemble the feedhorn, cut off the end of the down-converter PCB, and solder coax onto the PCB dipole.



the most common mod - coax soldered to the cut pcb

Of all the sites out there, ChrisK's page on his Galaxy modification was the most interesting, as he rebuilt the dipole from scratch, ensuring the measurements of the dipole and balun were as accurate as possible for operation at 2.4GHz.

ChrisK based his dipole on a design shown on this page, and Marcus and myself believed we could construct similar or better dipoles, and decided to use a brass plate for the dipole (instead of the thin brass tube which ChrisK has used).

To ensure the correct balun impedance of 50 ohms, the ratio of the inner diameter of the copper tube to the outer diameter of the brass rod should be approx 2.3.

The important dimensions are:

- length of the dipole is 1/2 wavelength
- length of the balun is 1/4 wavelength
- ratio of inner diameter of copper tube to outer diameter of brass rod

The 802.11b standard uses 2.412MHz to 2.484MHz frequency range, so at the centre of that frequency range, 1/2 wavelength is 61mm, and 1/4 wavelength is 30.5mm.

Below is a cut-away diagram showing the parts used in the construction of the dipole.

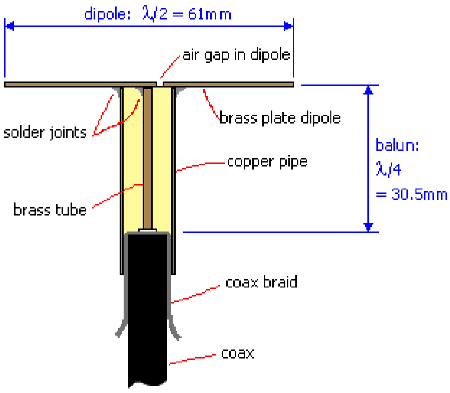


diagram showing components fitted together

Parts Required

The materials we used to perform this modification:

- Conifer (ex Galaxy) antenna
- low-loss coax (such as LMR-400 or CNT-400)
- 50mm of copper pipe (~10mm internal diameter)
- 61mm of flat brass bar (~12mm wide by ~0.5mm thick)
- 30.5mm of brass pipe (~4-4.5mm outer diameter)
- female n-connector

the raw materials: copper pipe, brass tube, brass plate

Most Bunnings and Mitre10 hardware stores should stock these materials - ask at the trade counter if you can't find them.
Alternatively, hobby stores should certainly stock these materials.

The brass plate I used is 12mm wide, and 0.6mm thick, while the copper pipe has an internal diameter of 10.8mm, and the brass tube is labelled as "3/16 round brass - stock no 129" with an external diameter of 4.5mm.
This means the ratio of the inner diameter of the copper to the outer diameter of the brass is 10.8/4.5=2.4, which is close enough to the required ratio of 2.3.

navigation: part 1 | part 2 | part 3

last updated 22 Oct 2013

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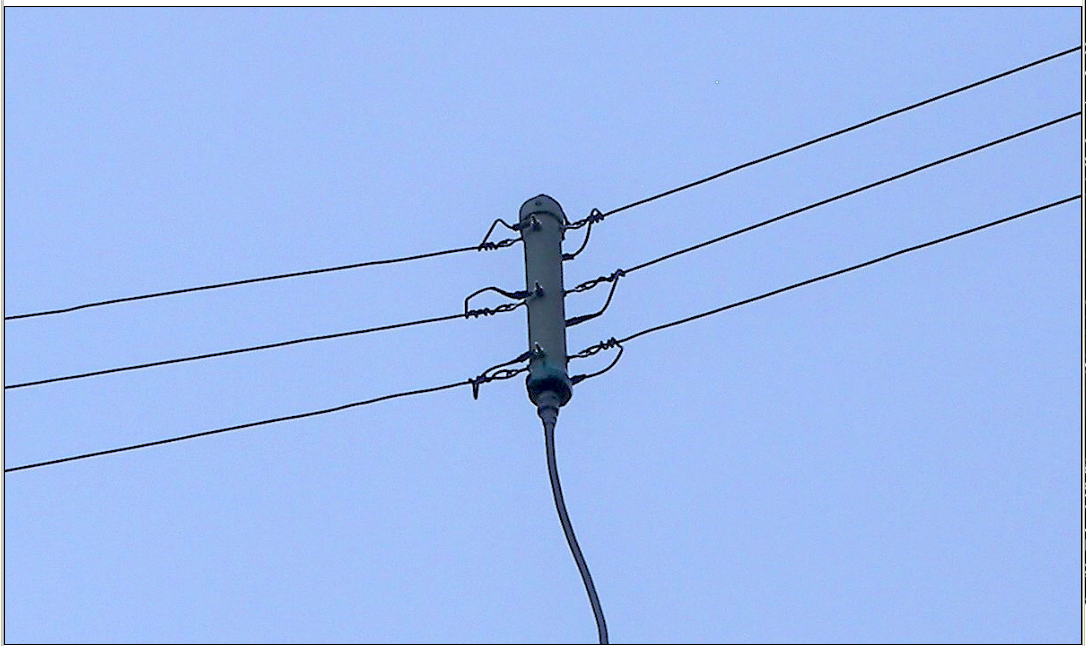
The KL3JM MODIFIED "SRI" MULTIBAND FAN DIPOLE FOR 80 - 40 - 20 Meters

I built my SRI dipole for three bands, 80, 40 and 20 and designed it to be as light as possible since there would be no center support, just hanging between two trees.



It was based on an article on Hamuniverse.com that can be seen here. In case you don't know what an "SRI" dipole is, read the article above in the link. The antenna in this project is a modification of the techniques used to design a multiband fan type dipole with little or no tuning involved.

Since I only had 105 feet between my trees I had to use a loaded wire for the 80 meter band at 90 feet long.

K7MEM has a good web site at www.k7mem.com that I used to get the specs for this short 80 meter section loading coil.
It was made with a 51uh coil set between a 9 foot and 36 foot wire for a total of 45 feet on each side. This 90 foot length set the design for the rest of the assembly.

The center connector/insulator was made from a 14 inch length of 1 1/4 inch PVC. See photo (1) below.

The 1 1/4 inch PVC is not big enough to get your hand in but much lighter than 3 or 4 inch PVC. While a bit like building a ship in a bottle, it wasn't too bad to get it together.

I used 6 stainless #10 eye bolts as wire anchors and 6 stainless #10 machine screws for the terminal connectors, 3 per side.
The terminals were spaced 6 inches apart, a bit more than the 5 3/4 inch spacing suggested in the original SRI design. (It is important to remember that all 3 center insulator terminals are wired together on each side of the center insulator making each half of the dipole parallel with the other band dipole legs on the same side. Each half of the dipole is connected to the SO-239 connector. One side of ALL of the dipoles is connected to center pin on the S0-239 connector and the side to the shield side of the connector.)

The three terminals for each side were connected with 12 gauge wire with ring terminals. The nuts and washers for the middle terminals and eye bolts were held in place by putting them on the end of a long screw driver with a bit of axel grease to hold them on the tip.

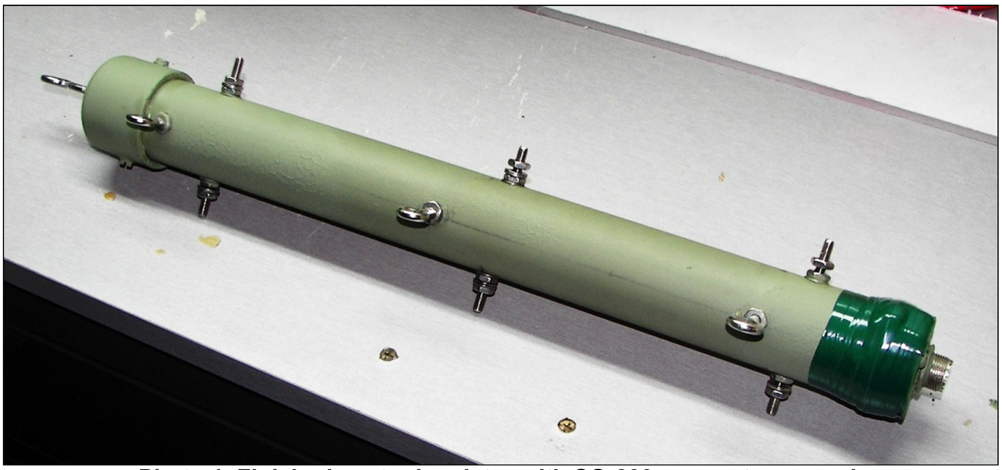
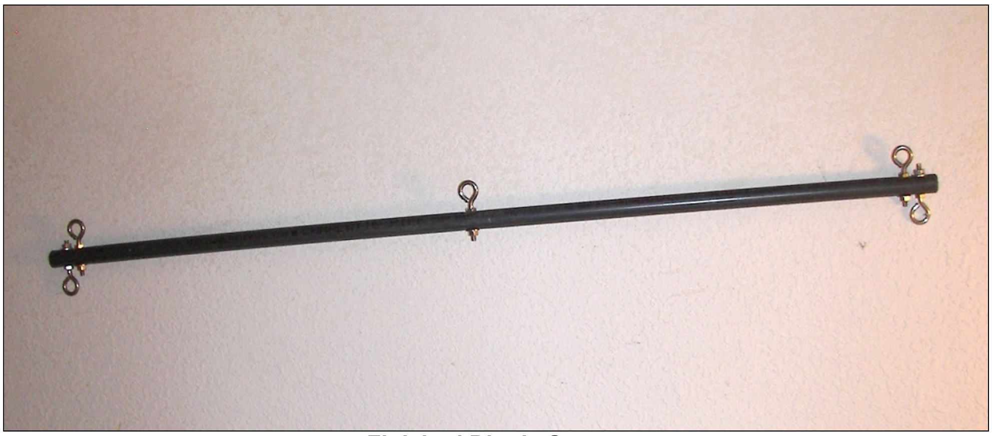


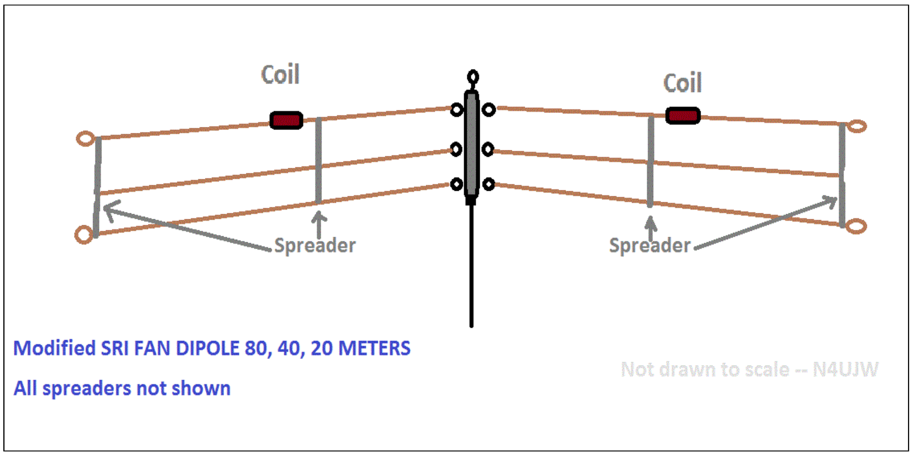
**Photo 1. Finished center insulator with SO-239 connector on end.
Dipole terminals spaced 6 inches apart.**



Finished Dipole Spacer

Note that the spacing between each dipole on the end spacer is 19.5 inches between each wire as suggested by the army's total length of 39 inches in the original SRI article. Although not mentioned in the article, small diameter PVC tubing can be used for the spacers (sometimes called spreaders) between dipoles or any non-conductive material.

Yellow drawn in lines represent separate dipoles with spacers.
80 meter coil is in upper right of picture.



I built the antenna on the ground and tuned all three bands with my MFJ analyzer.
The 80 meter wire started at 45 feet per side, the 40 meter wire at 32 1/2 feet per side and the 20 meter wire at 17 feet per side.

Starting with the analyzer on the top wire, each band needed to be shortened a bit. After about 5 adjustments all bands were resonant in the middle of the band with an SWR of 1.3 or less.

After raising the antenna up 64 feet to its final position and putting the analyzer back on, there was no need to lower it for more tuning. The same resonant points stayed as they were with SWR at 1.3 for the 20 and 40 bands and 1.8 for the 80 meter band. I have made a number of good contacts between Fairbanks and Miami with signal reports of S-6 to S-9 on all 3 bands.

I found this to be a simple and inexpensive multi band antenna to construct and I am very happy with the results.

73

Scott KL3JM
Don't forget to refer to the original SRI article on Hamuniverse.com

Email Scott for any questions here>> novak AT gci.net

An Simple, Easy to Build E-Probe Antenna for 20 KHz - 25 MHz

February 19, 2010 - By W5JGV

This article describes a simple but effective receiving antenna that covers a wide range of frequencies. It requires an amplifier which serves the dual function of amplifying the received signals and matching the high impedance of the short vertical antenna to the transmission line that connects the antenna to the various receivers inside the shack.

The W5JGV E-probe antenna as installed in Natchitoches, Louisiana, USA.

The antenna consists of a 9 foot (2.75 Meter) length of #10 AWG copper wire. The wire is enclosed in the gray PVC pipe. The wire need not be insulated. The top and bottom ends of the PVC pipe are capped with glued on slip on pipe caps which ensure that water does not get into the antenna.

The amplifier for the antenna is inside the translucent plastic box seen mounted on the wooden support pole. The amplifier is the same amplifier which was used with my Tree-Tenna. The amplifier is powered by DC over the coax from the shack. Please click HERE for information about the amplifier.

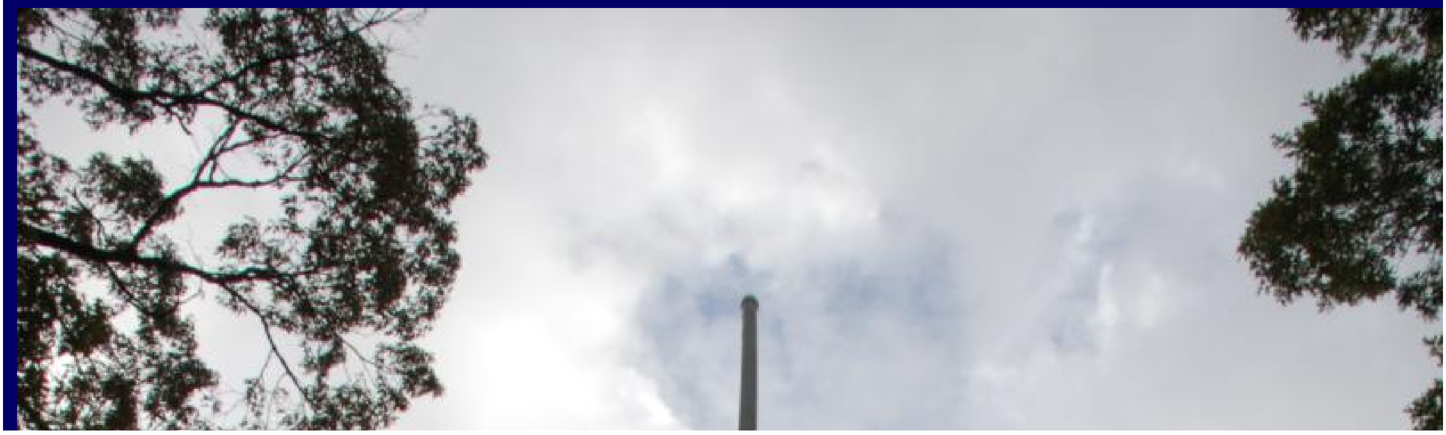
An 8 foot (2.45 Meter) copper-clad ground rod is driven into the earth at the base of the support pole. The coaxial cable between the amplifier and the ham shack is RG-6 TV coaxial cable. The amplifier and the shield of the coaxial cable from the ham shack are both connected together and connected to the ground rod. For ease in troubleshooting, the coaxial cable is spliced and fed through a standard TV cable grounding block. The ground block is located under the translucent blue plastic rain shield mounted on the support pole beneath the amplifier.

To prevent the PVC pipe from bending and breaking under wind stress, the lower end of the pipe was reinforced by slipping a length of the next larger PVC pipe over the antenna pipe. Standard pipe mounting "U" straps were then used to attach the antenna pipe to the mounting pole.

The bolt seen protruding through the white pipe cap is connected inside the PVC pipe to the lower end of the #10 gauge copper antenna wire. Stainless steel nuts hardware was used for this connection to prevent corrosion.

Because you cannot easily slip the PVC antenna pipe into the reinforcing section of PVC pipe, it was necessary to cut the larger reinforcing pipe lengthways along one side only. That allowed enough flexibility in the reinforcing pipe to be able to force the smaller pipe into the larger. It was a tight fit!

The antenna pipe as mounted on the weather treated 4X4 wooden support post.

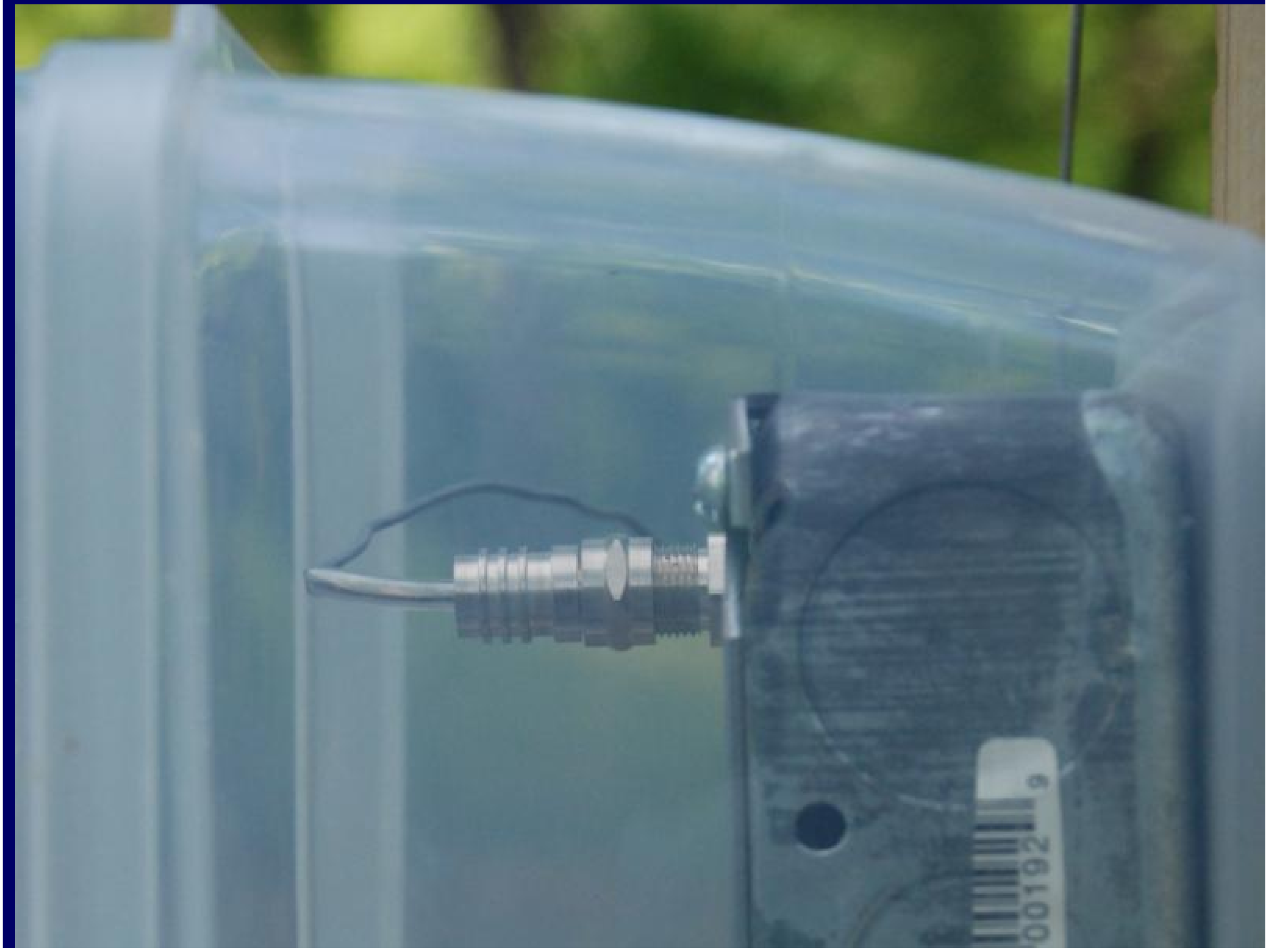


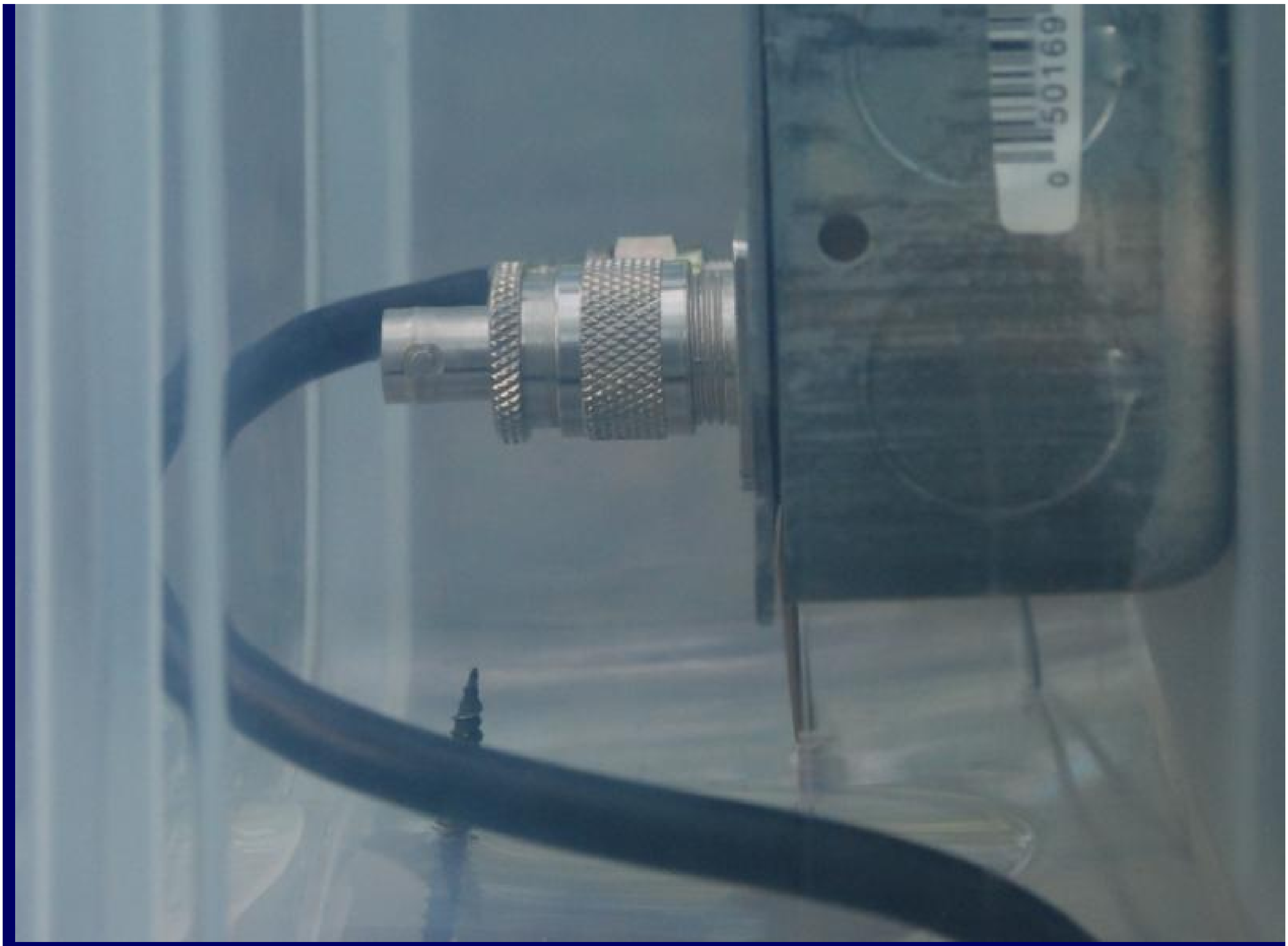
Even though E-Probe antennas are not supposed to work well when located close to trees, as you can see, the antenna is located amongst a grove of large trees. Nevertheless, the antenna performs admirably.

The W5JGV E-Probe antenna before the amplifier and coaxial cable were installed.

The W5JGV E-Probe antenna ready for use.

The amplifier is seen inside its protective enclosure, and the aluminum wire connecting the antenna to the amplifier is just visible to the left of the amplifier. The ground block and coaxial cable termination point is under the blue rain shield. The top of the ground rod is visible just in front of the wooden support post. A few extra turns of coax cable were left coiled around the base of the antenna just in case something happened to the cable, such as a lawnmower accident, or a squirrel or raccoon gnawing on the cable.





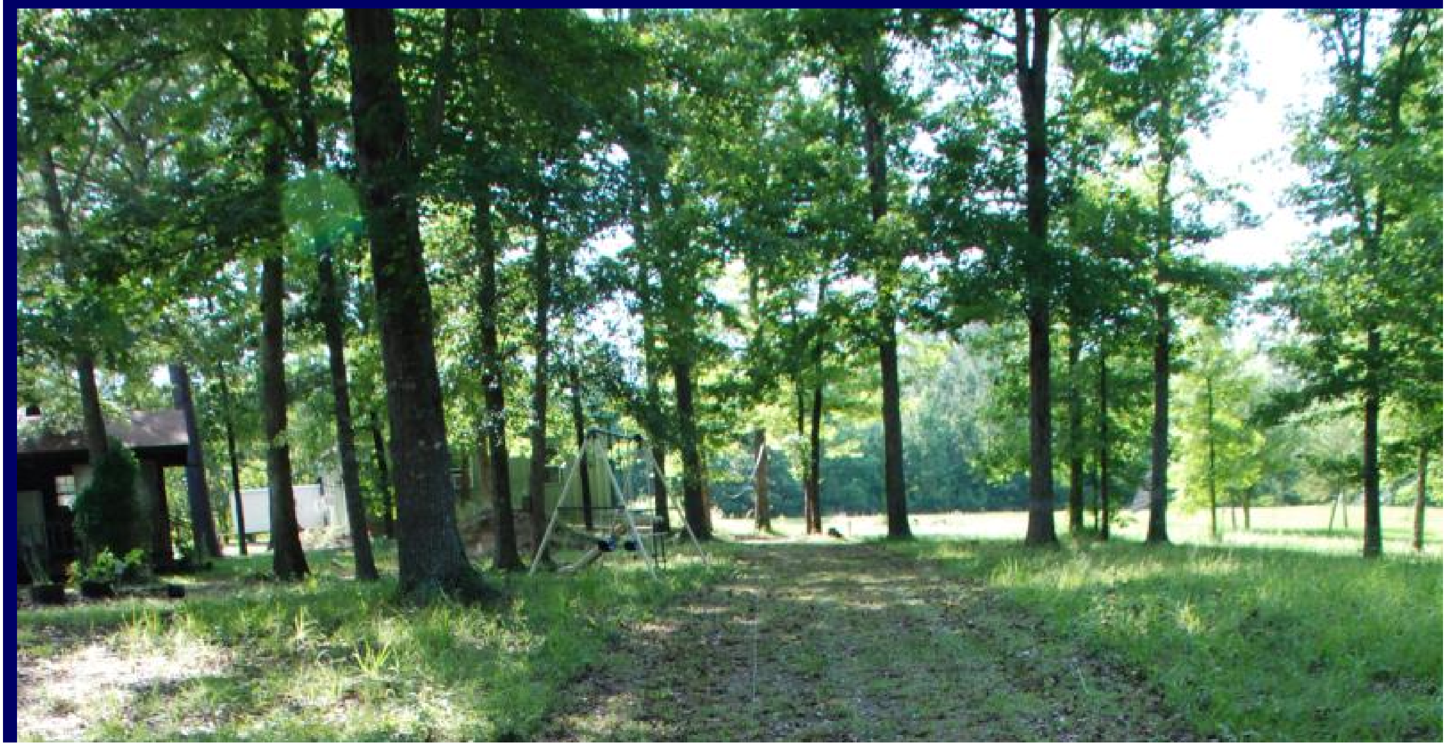
The amplifier is enclosed in a metal electrical box and then placed inside the plastic enclosure. (Note to self: Use a better quality plastic box the next time! This box deteriorated in two years time, and the hinge broke, allowing the cover of the enclosure to flop open.)

Note that the bare aluminum wire from the bottom of the antenna is just stuck into the center connection of the "F" connector on the input of the amplifier. Because the amplifier's input has a very high impedance, coaxial cable should not be used to connect the antenna to the amplifier.

The UHF to BNC adapter seen here is used for connecting a portable receiver to the output of the amplifier for field tests, and is otherwise not used. The coaxial cable connecting to the second "F" connector behind the UHF/BNC adapter is the RF output/DC input of the amplifier.

The connecting wire between the bottom of the antenna and the amplifier input.

The antenna is almost invisible amongst the trees in this photo. The antenna's location is about 200 feet (61.2 Meters) away from the ham shack and slightly downhill from the ham shack. The coax cable from the antenna to the ham shack is simply laid on the ground and left there. RG-6 is cheap, so if it gets damaged, it is simple to replace it. The cable runs from the antenna up the hill to the left and then on to the ham shack.



Looking up the hill towards the ham shack, you can see the cable laying on the ground. I used the lawn mower and cut the grass and weeds very close to the ground so the cable was pretty much laying on the bare earth. After a year, the cable has become invisible under the new grass.

The cable makes a bend or two as it gets closer to the shack. The bends are "pinned" to the earth by using short lengths of metal tube bent into a "J" shape.

The cable runs along the ham shack foundation until it reaches the cable entry box on the wall of the shack.

Here the cable turns up and enters the shack through a length of PVC conduit and through the cable entry box. There is a grounding plate through which all of the antenna cables pass to and from the shack.

Well, that's about it. Hopefully this article will inspire you to build your own E-Probe antenna.

As you can see from this article and the one on the AMPLIFIER, there are no expensive components required.

Operation of the amplifier from late 2007 through early 2010 has been flawless. No component failures have occurred. the antenna has operated perfectly during sun, rain, snow and thunderstorms.

The signal output from the antenna is split in the shack into six separate RF feeds for various receivers. frequencies in use range from 20 KHz through 25 MHz.

73,

Ralph - W5JGV - WD2XSH/7

[BACK]

The genset weather screen surrounding the 5 KW Onan genset.

Yep! It's really in the kitchen!

The black case on the table holds the engine starting battery, which is kept charged by a small automatic battery charger. The yellow tube carries propane fuel to the generator engine. There is an electric solenoid valve that cuts off the fuel supply whenever the genset is not running. The genset is on wheels so it can be moved, but here it is mounted up on concrete blocks in this semi-permanent installation.

There is a white plastic carpet screen mounted upright just to the right of the genset cooling fan. Since the unit was designed to exhaust the cooling air downwards, it was necessary to redirect the exhaust cooling air upwards towards the ceiling where it exits the area. Note the exhaust pipe simply ends in a small muffler right above the genset. Since the area is well ventilated, this is adequate, but I don't allow anyone to stay in the area for very long when the genset is running.

The combination of the weather screen and wooden walls on the other three sides of the kitchen area make the running noise surprisingly low from more than a few yards away. In any event, there are no close neighbors around to complain! There is a manual safety disconnect switch to disable the genset when working on then system, and a smoke detector is installed in the overhead. This shuts down the genset and turns off the fuel supply should a fire or smoke situation occur.

This junction box contains the electronic logic and generator fuel lockout relay that stops the generator is the smoke detector is tripped.

A view from the generator looking at the backside of the weather enclosure. It's simple, but sturdy enough to handle most storms. Note the gap between the floor boards. These let cooling air into the area from beneath the raised deck. Hot cooling air and exhaust gasses rise to the top of the area and flow outside over the top of the right side wall of the enclosure. There's lighting and a ceiling fan for operator comfort when working on the genset.

The existing electrical system had a 200 Amp load panel which was connected directly to the utility meter. I had to break into the circuit and install an automatic transfer switch and the necessary components to allow me to operate both my existing 5 KW genset and the new 27 KW genset I have ordered.

However, before I could start upgrading the electrical system, I had to figure out how to keep basic stuff such as the refrigerator and freezer running while I ripped everything apart. Since the old garage I am using as a workshop has its own separate power feed, I decided to borrow some power from the to backfeed the load panel in the house until I completed the electrical system upgrade.

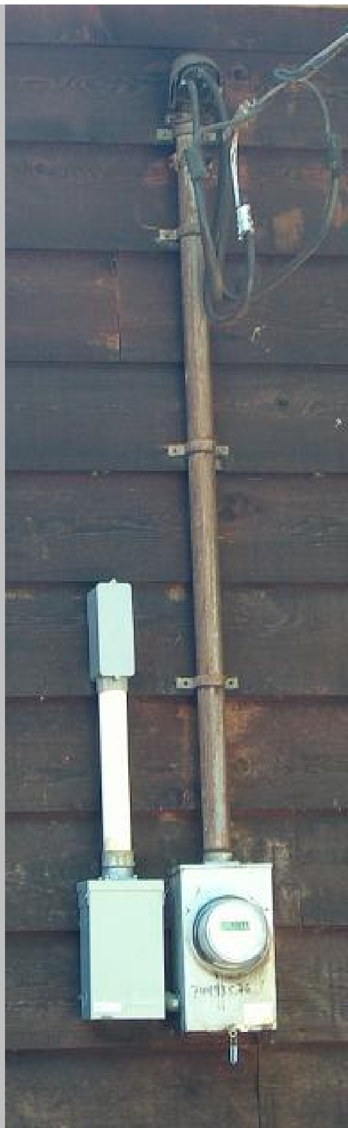
It is about 125 feet from the shop to the house, and I knew I could not get enough power by simply stringing an extension cord between the buildings. Something better was needed. I decided to build my own high voltage transmission line. Looking through the Junque I had lugged here from New Orleans, I located a pair of 5 KW transformers that looked as though they would work. Here's a picture of one of them that I placed at the house end of my temporary High Line.

The two transformers were set up to step up the 240 volts from the service at the workshop to 480 volts, and then back down to 240 volts at the house. Since they were rated at about 5 KW each, I was able to use 12 Gauge Romex between the transformers for the 480 volt section. (Yes, the Romex is rated to 600 volts - I checked!) Some heavier 8 Gauge cable connects to the 50 amp air conditioner breakers in the house load panel to backfeed the panel. In the shop, the other transformer is fed from my welding machine outlet.

Here you can see the garage is still full of stuff from the move. Most of this will go into the new building that will be the ham shack / art studio / storage building. You can also see the yellow Romex wire leading from the power transformer back to the shop, and the black cable going to the house load panel.

From tree to tree, the high line makes its way from house to shop. (You have to look closely to find the wire.)

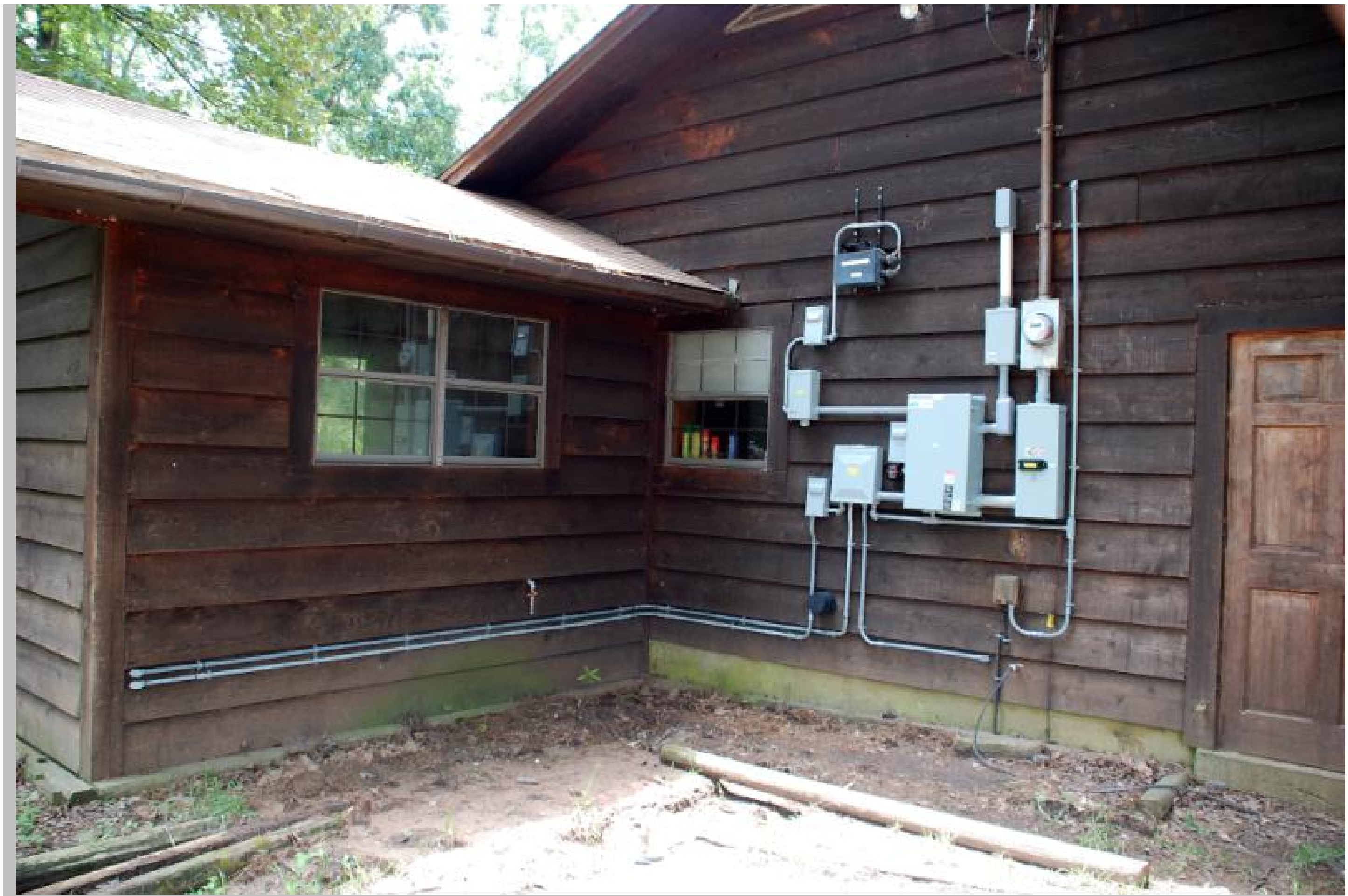
Let's see what I had to start with before I began this project...



As you can see, things were pretty simple. There was just the meter panel, and an add-on circuit breaker box for the electric furnace. The load panel for the house is located directly behind the meter panel.

What I needed to do was to install a generator automatic transfer panel and the necessary hardware to make everything work by itself. There's a lot to do...

Low let's look at an overall picture of what's been done to this point.



The 5 KW generator is mounted in the outside kitchen at the left side of this picture. The lower of the two gray conduits feeds running along the wall carry the AC power from the genset to the electrical panels, while the upper conduit contains the low voltage control wires that operate the genset.

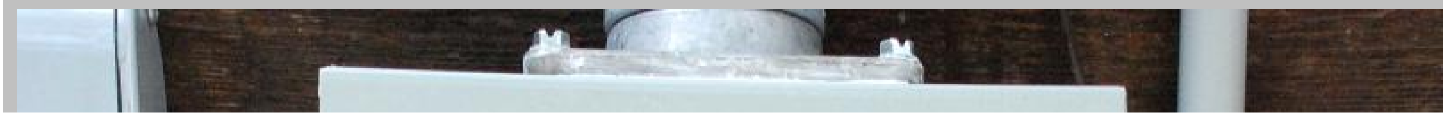
Visible in the bottom of the picture is the new slab for the 27 KW genset.

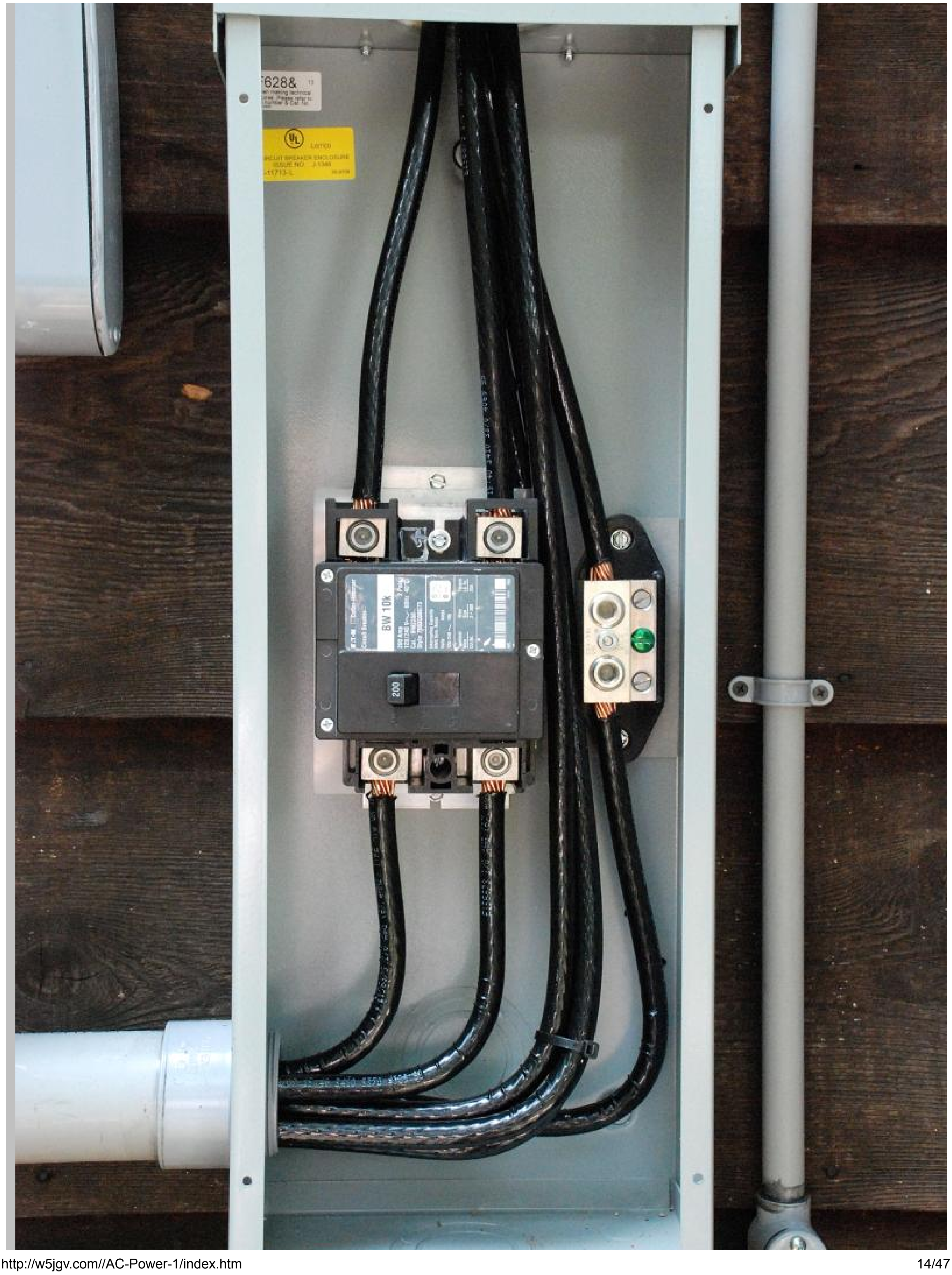
Starting from the utility company's weatherhead, the incoming power drops down to the meter panel. Originally, the power then went straight through the wall into the house where it fed the load panel. The gray electrical box that has the white PVC conduit going up the wall from it and that is mounted just to the left of the meter panel has the 80 amp circuit breakers for the 20 KW electric furnace, which was added to the house several years ago.

Originally, these breakers were fed through a short conduit jumper that ran between the meter panel and the breaker box. I left the conduit in place, but rewired the breaker feed. This original setup did not have any overall main breaker arrangement, which meant that I could not easily install a transfer switch for the genset.

After arranging to backfeed the load panel from the shop, I ripped out the wires from the meter panel to the load panel and the furnace breakers. I reconnected the wires from the meter panel through the new 200 amp main breaker (in the box right below the meter panel) and fed them to the normal input connections on the automatic transfer switch (ATS). Then, I routed the feed from the transfer switch back through the main breaker box and the meter panel, thought the wall of the house, and into then load panel.

At this point, I was able to restore utility power to the house while I worked on the rest of the system.





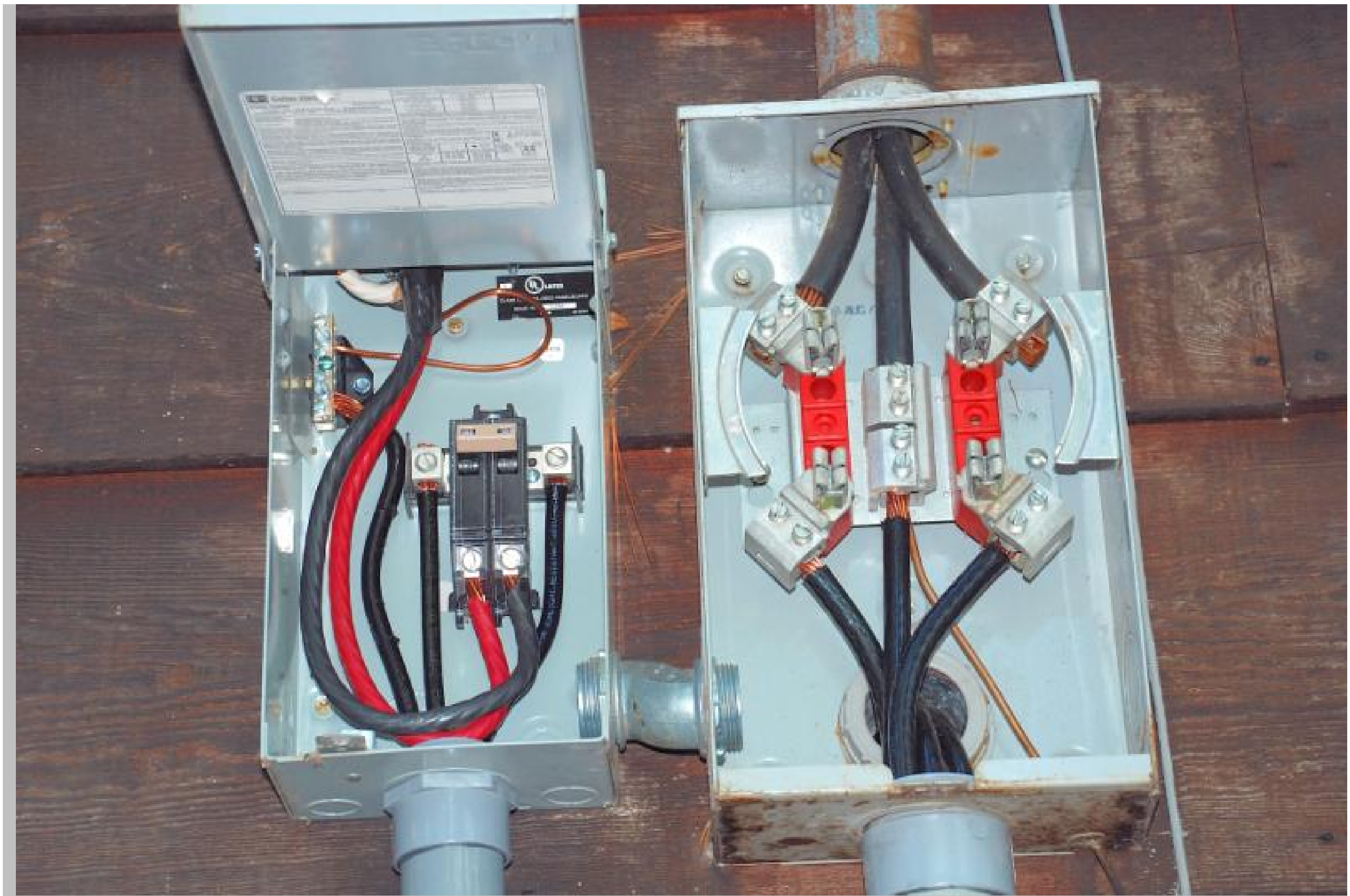
The new 200 Ampere main breaker cabinet.

The ASCO automatic transfer switch shown with the weather door open, showing the dead front panel. The control panel for the ATS can be seen in the upper right of the picture. The conduit visible at the lower right of the ATS carries the feed from the 200 Amp main breaker to the ATS. The conduit coming from the upper right of the ATS now feeds the electric furnace circuit breakers. The small conduit visible below the ATS cabinet carries control wires.

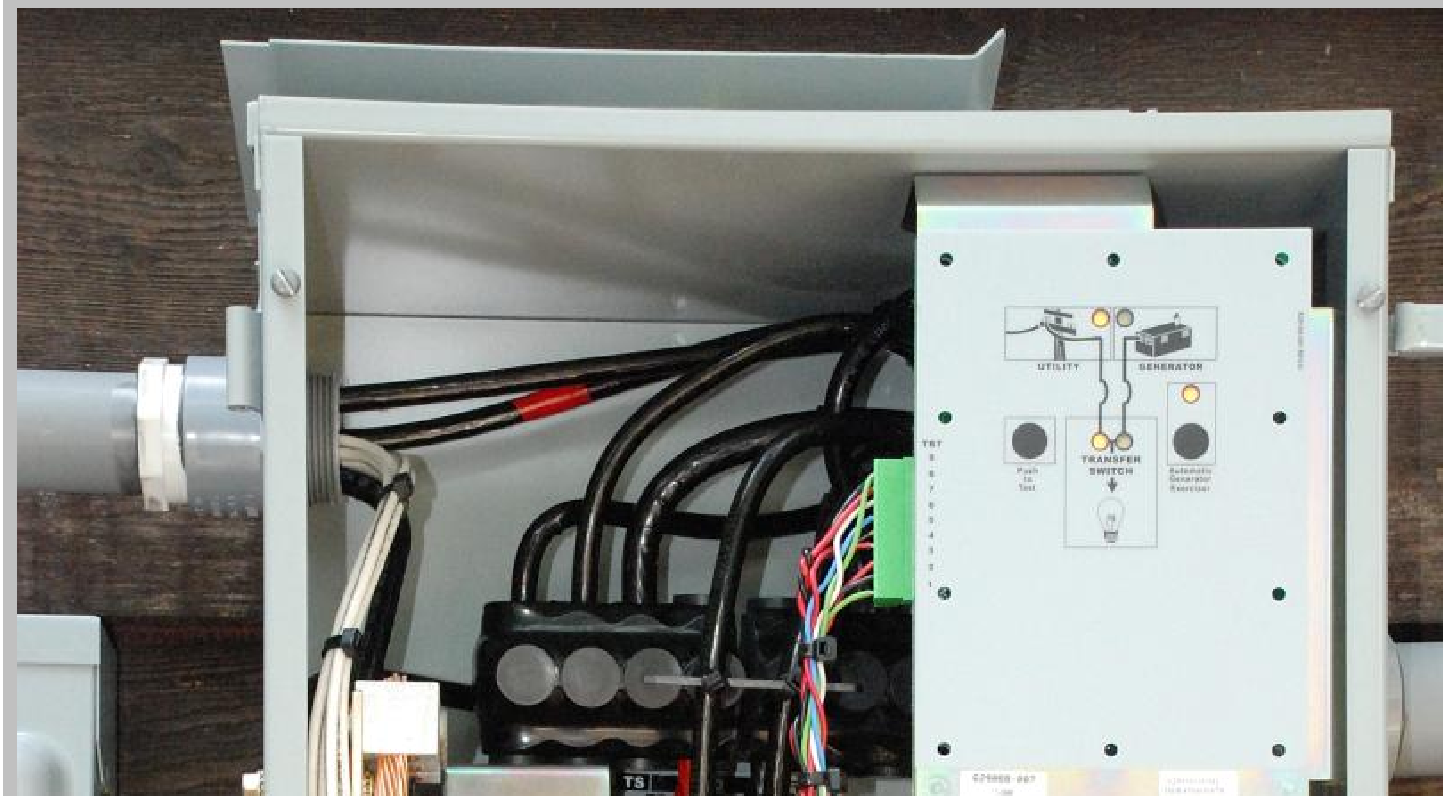
A view of the panels when they were partially wired. Here, the control electronics have been removed from the ATS for ease in connecting things.

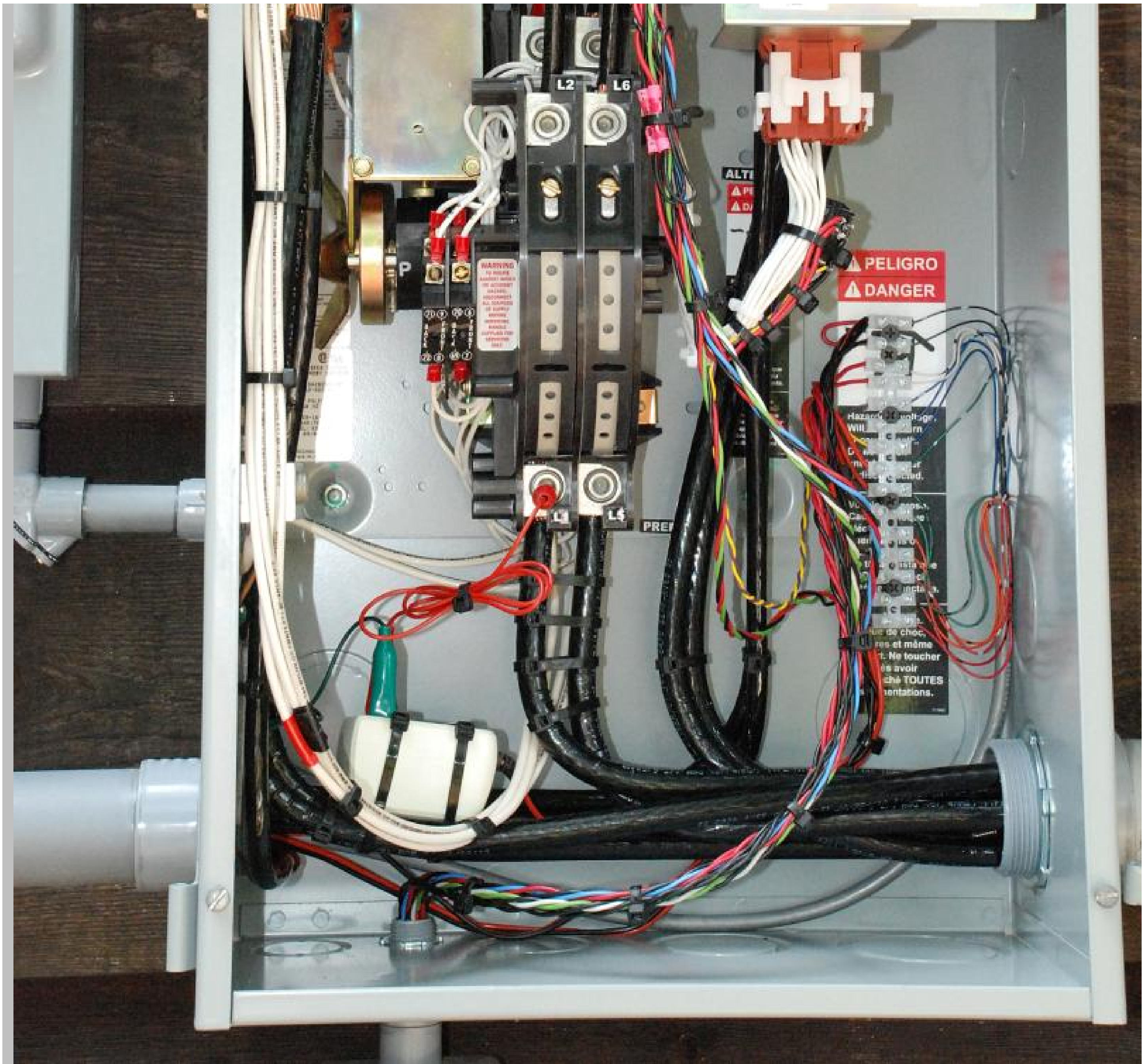
The cabinet on the far left is used to select between either the 27 KW or the 5 KW gensets, Both the control circuits to the gensets and the AC power from the gensets are switched in this cabinet. Between this control cabinet and the ATS is mounted a small black box, which is a Transient Voltage Surge Suppressor (TVSS). This is connected directly across the incoming utility power line. Directly above the TVSS is a 2-pole fuse assembly to protect the TVSS and its wiring from vaporizing should the TVSS fail shorted.

The TVSS and its fuse box.



The meter panel and the electric furnace circuit breakers. Note the old unused conduit jumper between the two cabinets.





This is looking inside the ATS after everything has been wired up and functioning properly. (Yay!)

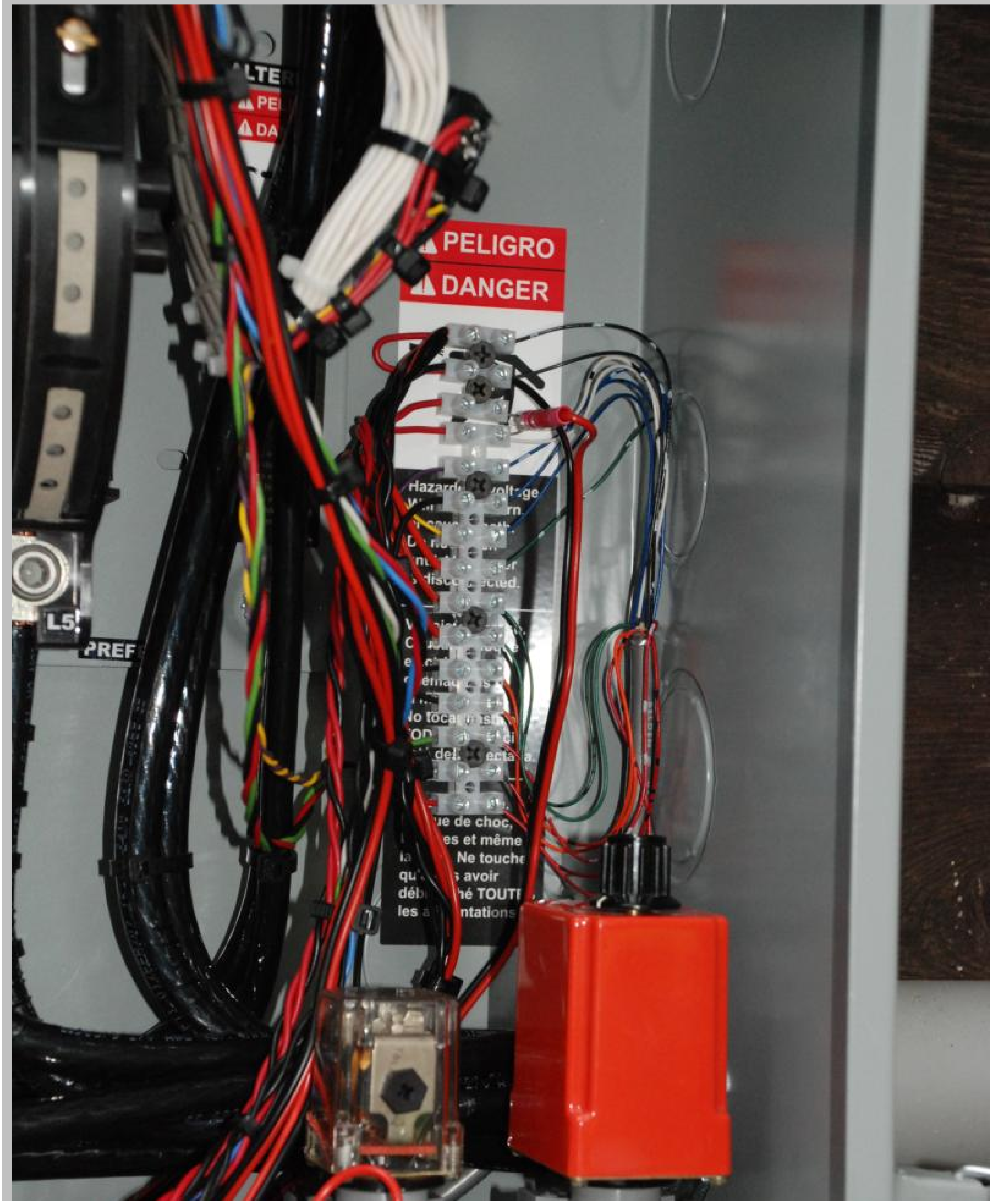
The control panel is in the upper right. The green plug connects to a rotary switch in the genset selector cabinet where the in-use genset is selected. The panel controls the engine start and stop, and operates the electric fuel valve.

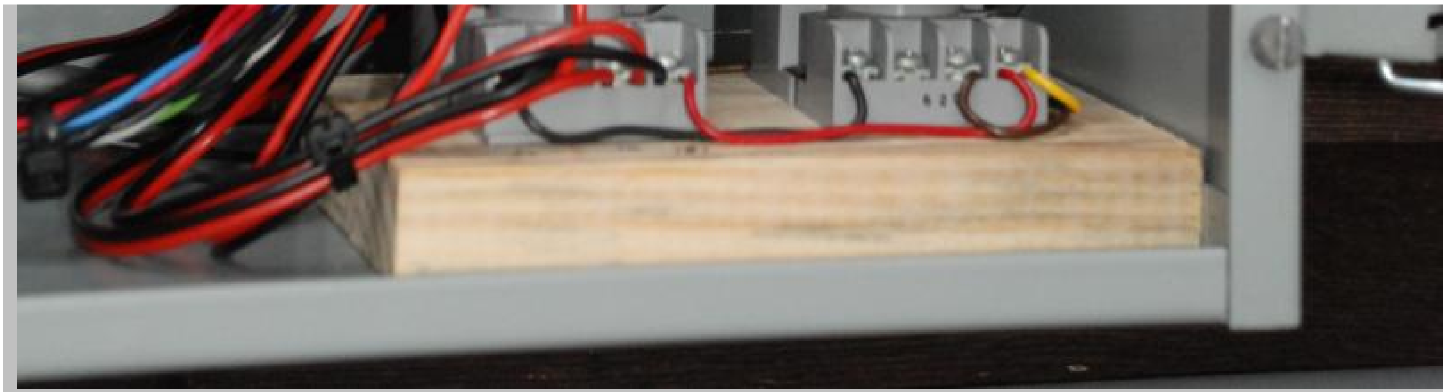
The orange plug with the white wires connects the guts of the ATS to the ATS control panel. A terminal strip has been screwed to the back of the cabinet over the manufacturers obligatory safety warning label. The terminal strip is for various control wires that go inside the house and connect to a small monitor and control panel for the gensets and ATS.

A white Radio Shack wall-wart is tie-wrapped to the power cables in the lower left of the cabinet. It is used to monitor the utility power feed.

The actual transfer switch is visible just to the center left of the panel. Directly above the main ATS switch is a pair of black wire adapters for feeding the house loads from the output of the ATS.

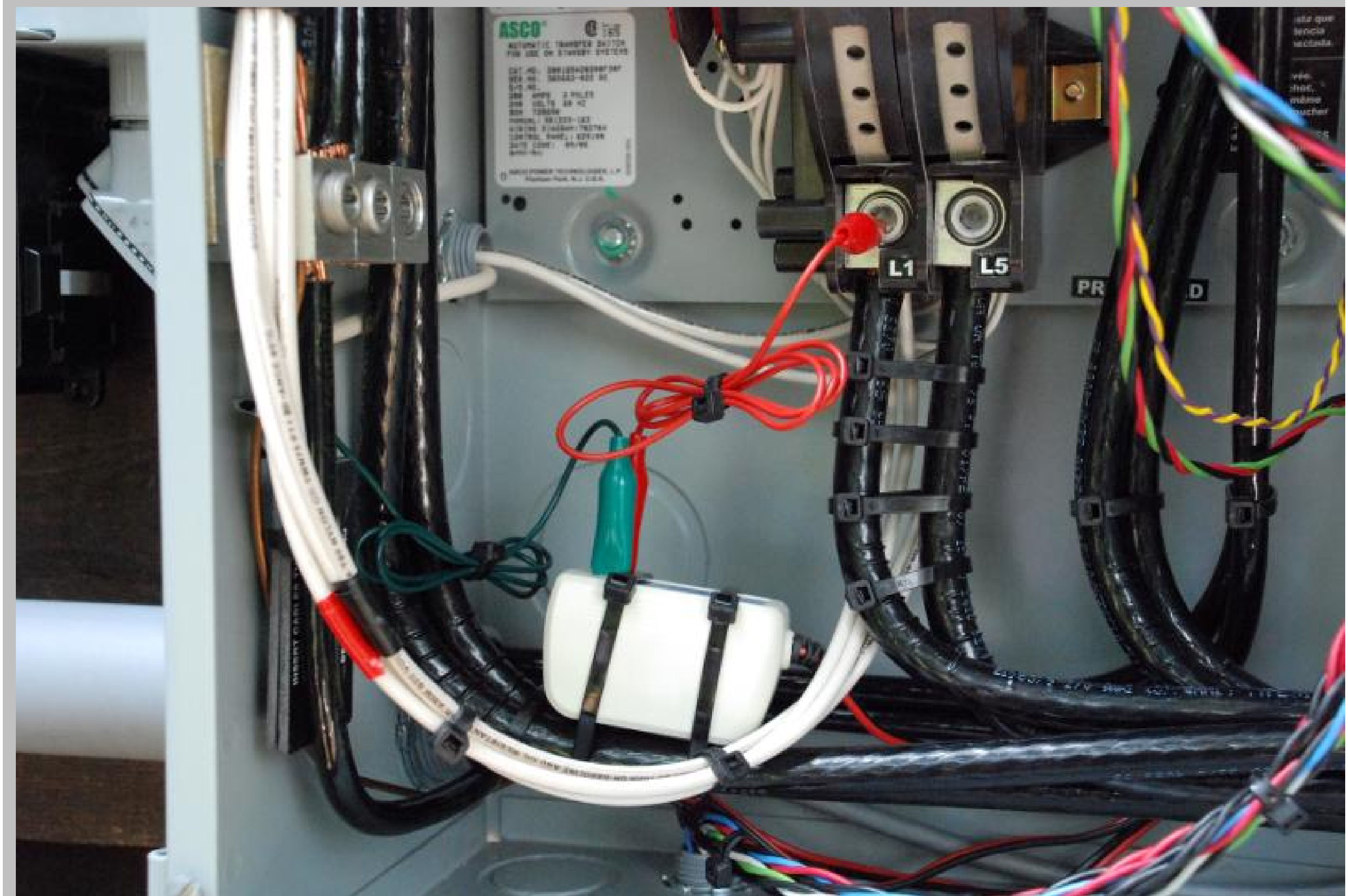
The utility power feed comes in at the bottom of the switch assembly. At the top of the switch are two pairs of terminals. The front set are connected to the output of the generator(s), and the rear set are the output from the transfer switch.



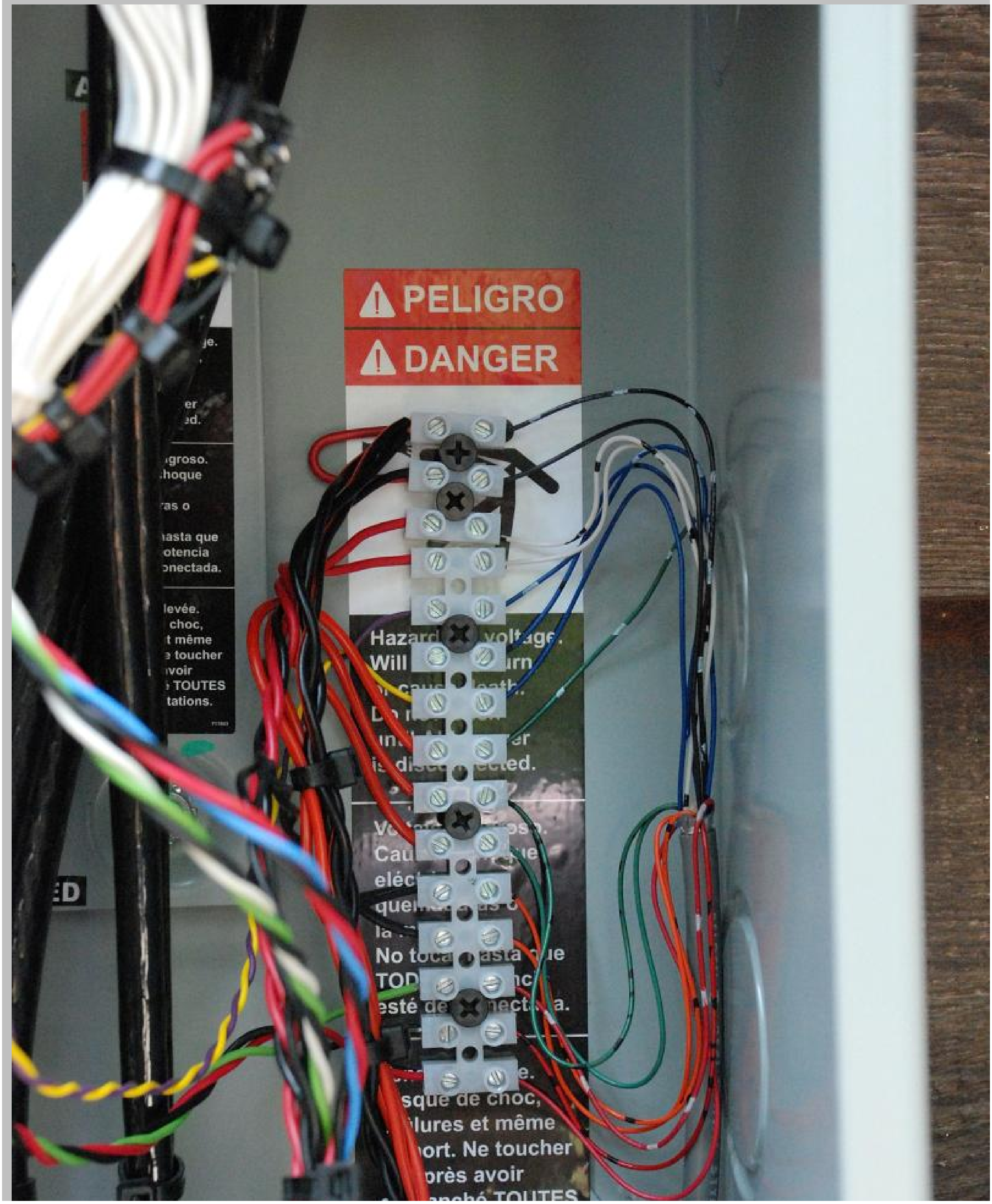


As it turned out, I had to install a time delay relay system in the engine cranking circuit to get the genset to start properly. It seems as though the transfer panel control logic is too "quick on the trigger" and as soon as it sees the alternator start to produce and AC voltage, it decides the engine is already running and shuts of the engine start signal. Of course, the engine is not actually up to speed, so it comes to a stop, whereupon the control logic does a restart, with the same result. After three attempts to start the engine, and three failures, the control panel locks out the start circuit. Then I have to open the transfer panel and press the reset button and manually start the engine. This is not good.

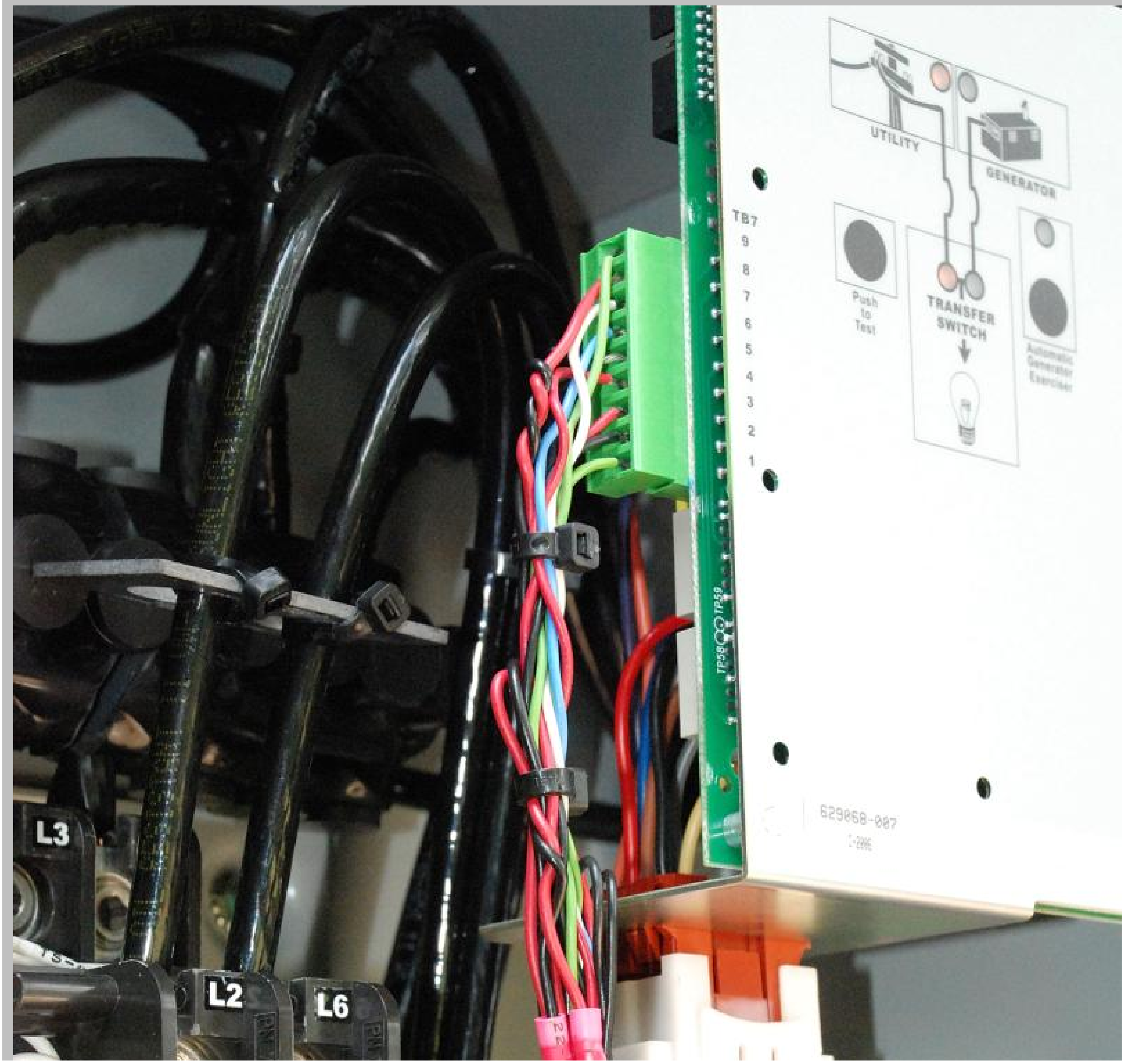
The delay relays keep the engine starter engaged for four seconds, no matter what happens. This is enough to ensure the engine starts normally, even if the transfer panel control logic terminates the start signal prematurely. Should the engine not start within four seconds, the transfer panel logic will keep the starter engaged for a maximum of ten seconds. If the engine has not started by that time, something's wrong!

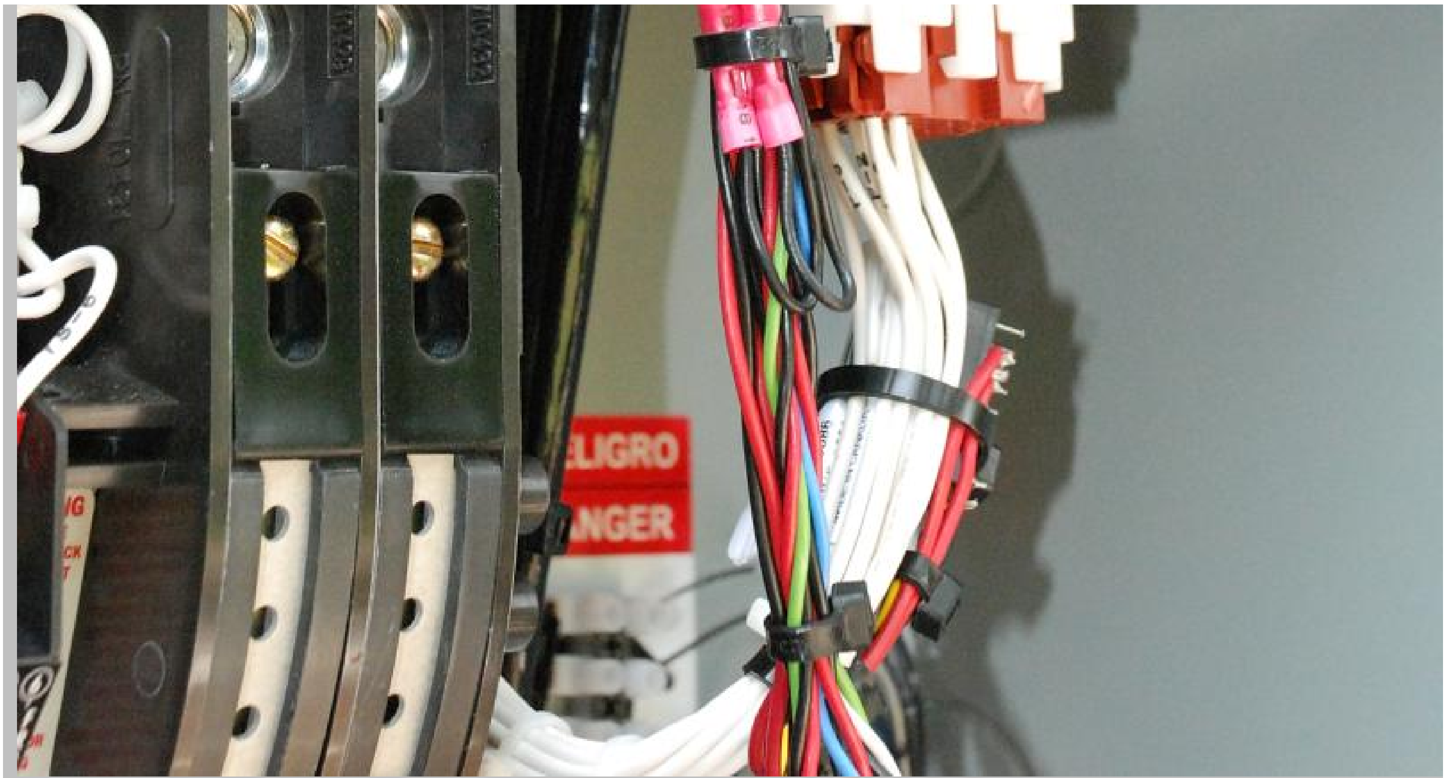


If you're an electrician, you'll cringe at this one! The wall-wart is connected between neutral and the utility line with a pair of Radio Shack clip leads. Chances are the wall-wart will never fail shorted. But if it does, you can be sure those famous RS 5 Amp clip leads will vaporize instantly! (So much for fuses.)

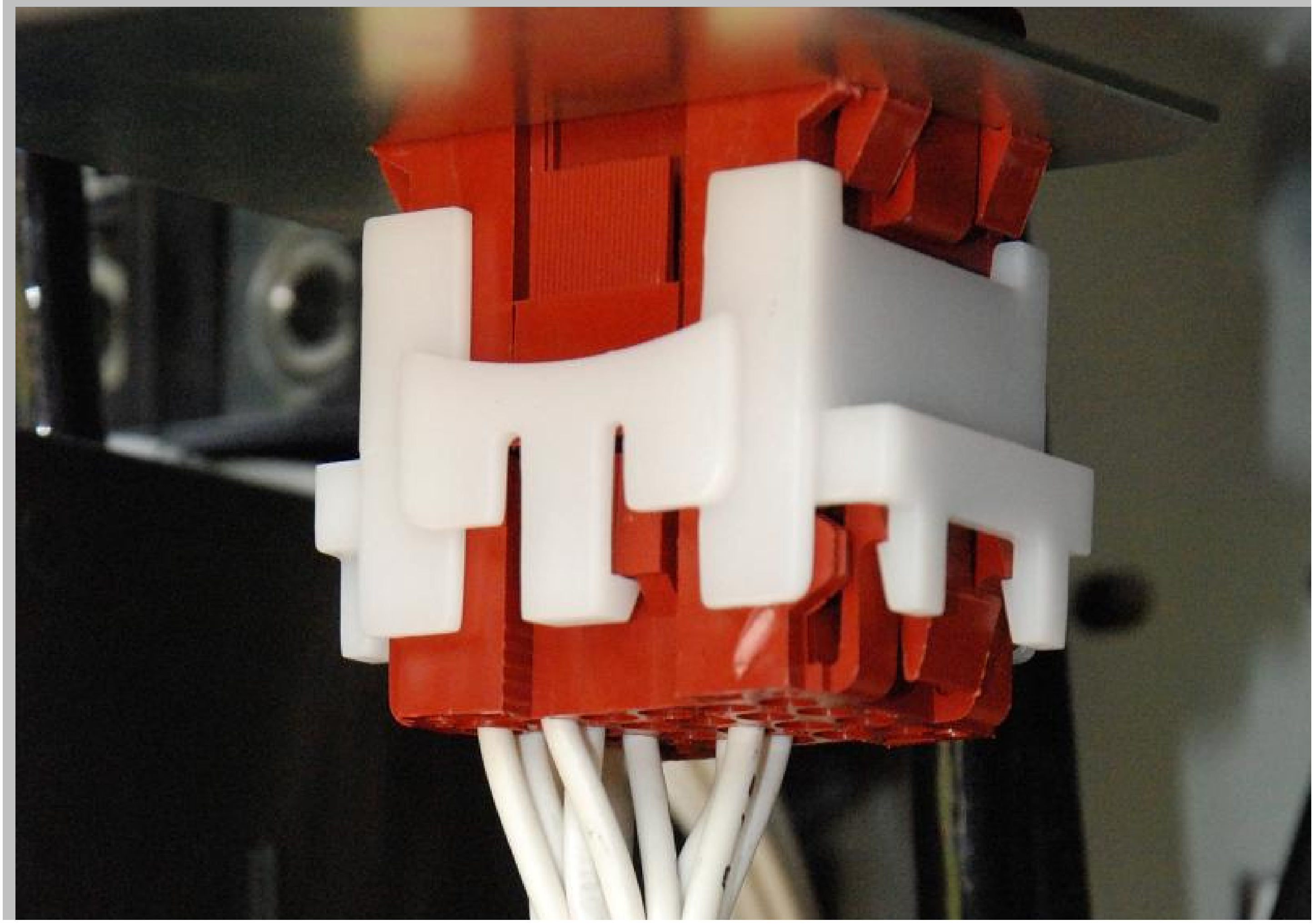


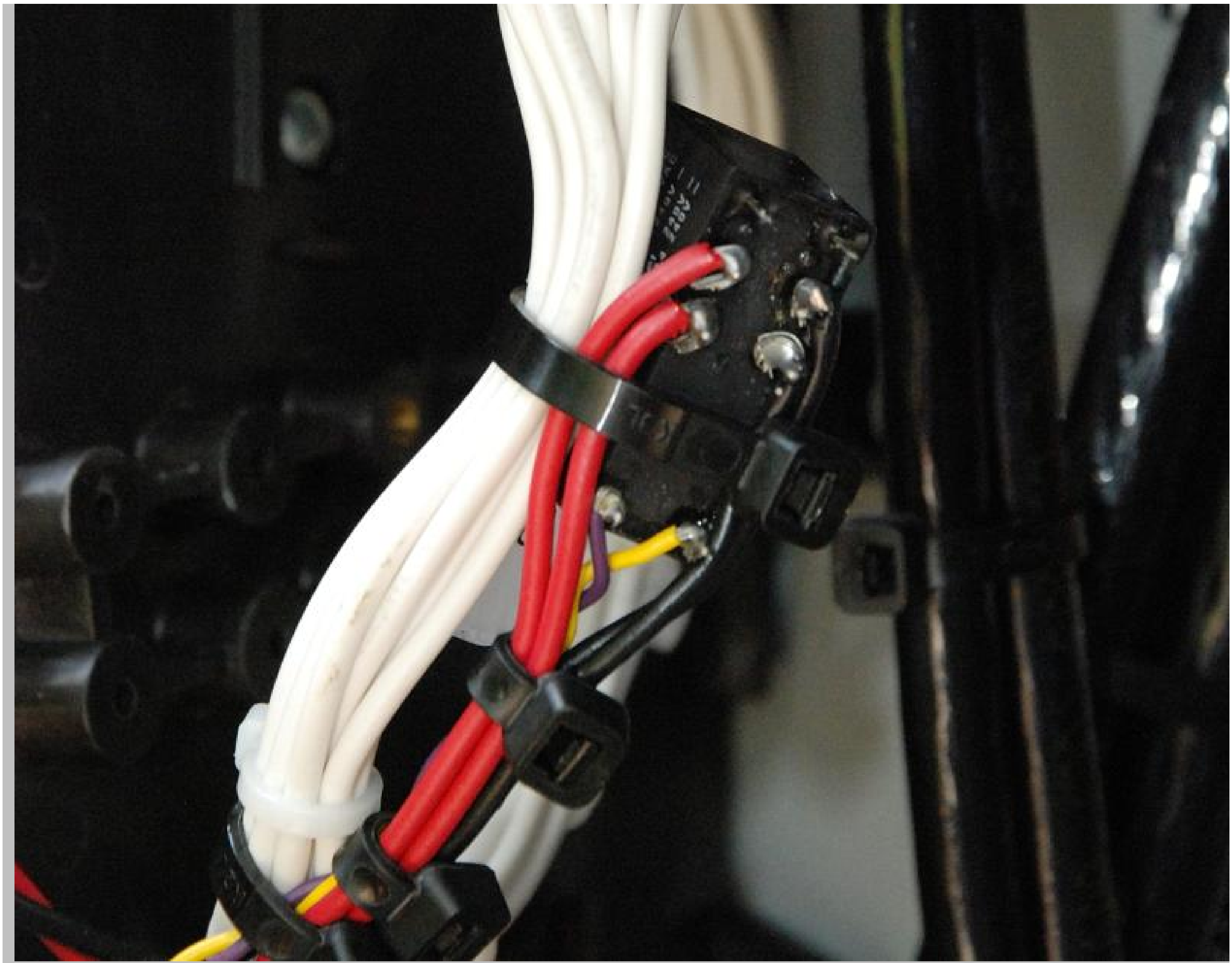
The gray cable from the right of the terminal strip goes into the house for control and monitoring of the genset and the ATS.



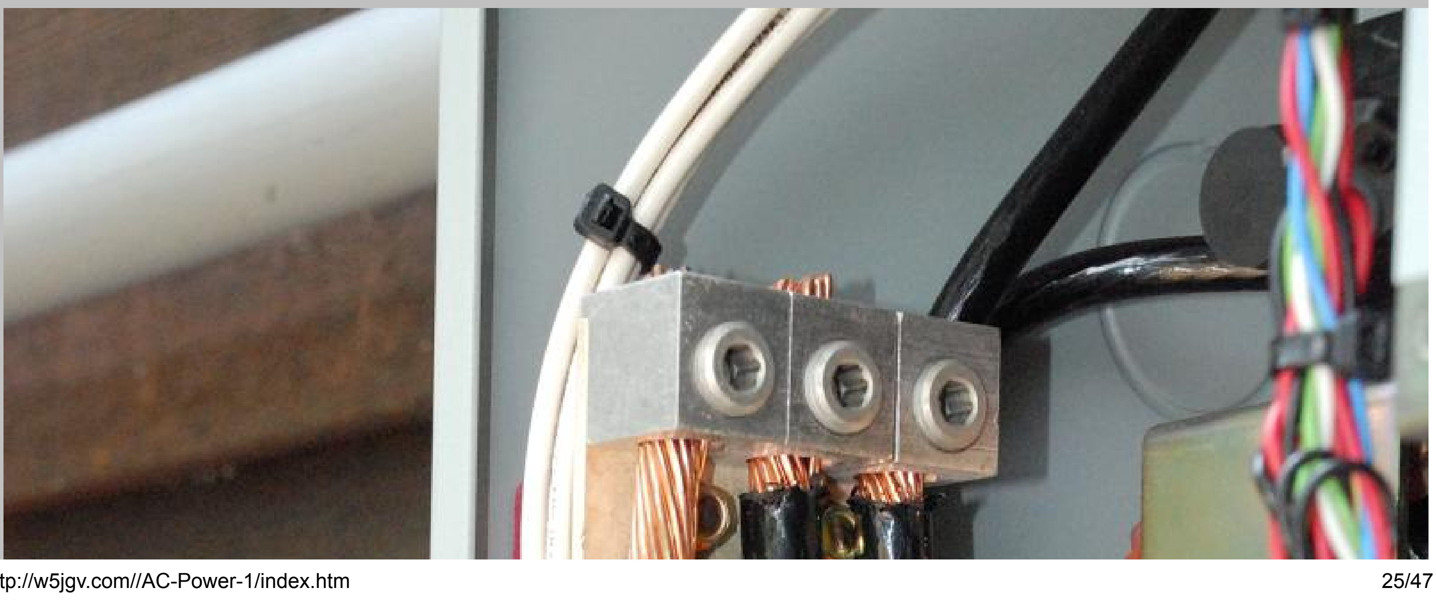


The wires from the plug on the ATS control panel that control the gensets.



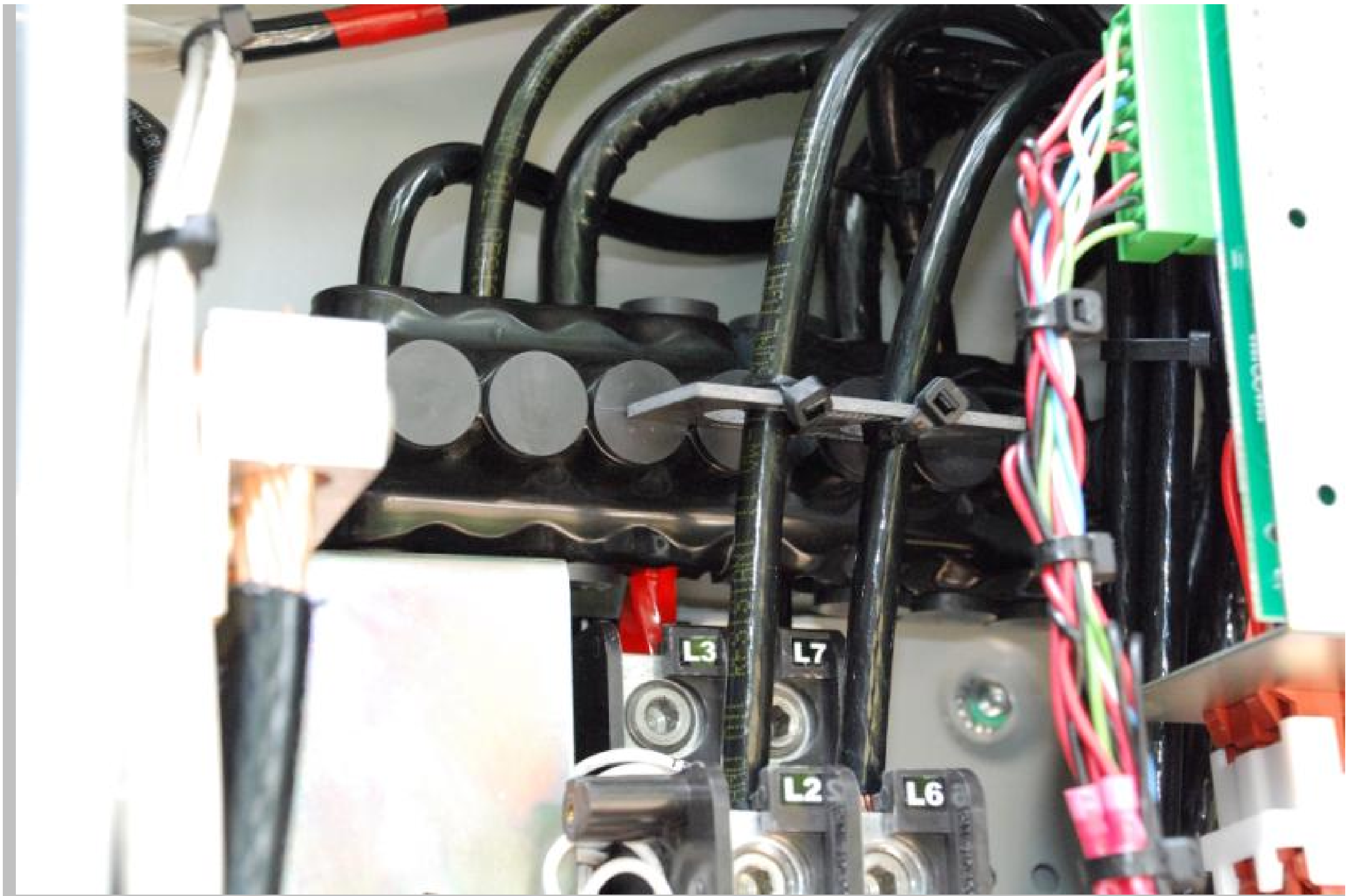


The white wires connect the ATS switch to the ATS control panel. Note the small black relay that's tie-wrapped to the wires. It is controlled from inside the house and is used to prevent either of the gensets from being started by the ATS control panel. This is used for genset or ATS service or if we are away from the house for an extended length of time and do not want the genset to run in the case of a power failure.



There's a whole lotta' grounding goin' on!

In the local utility's scheme of things, the neutral and earth connections are bonded together. I had lots of connections to make to neutral/earth, so both blocks were strapped together as you see here.



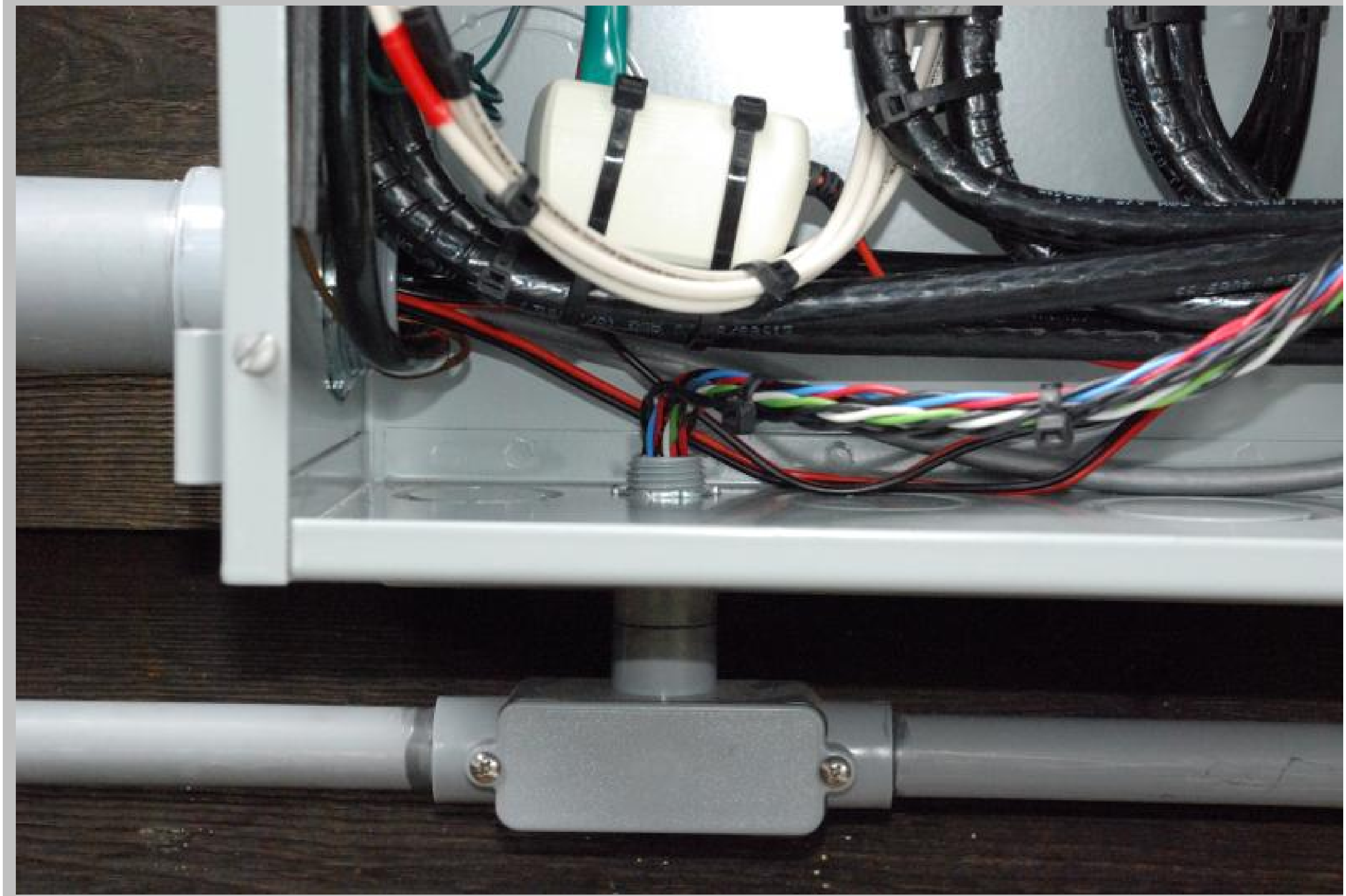
Since our plans call for a second building for Bonnie's art studio and my ham shack, I wanted to be able to feed it from the existing power system. That meant that I had to be able to route the output of the ATS in three directions at once. I have to feed the original house load panel (200 A), the electric furnace feed (80 A) and the new building feed (125A). Since it was impossible to stuff all those wires into the ATS terminals, it was necessary to use a couple of very handy adapters to do the trick.

I needed two connectors that would handle four 2/0 wires on each connector. I found some (actually just one - this is a small town) sold by Polaris, but it was made to handle eight wires. I needed two that would handle four wires each. Hmm... Let's see - eight divided by 2 equals four, so... off to the bandsaw. Ten minutes later, I had the two connectors I needed. Some liquid PVC insulation was applied to the cut ends and allowed to dry for a few days. Just like factory made!

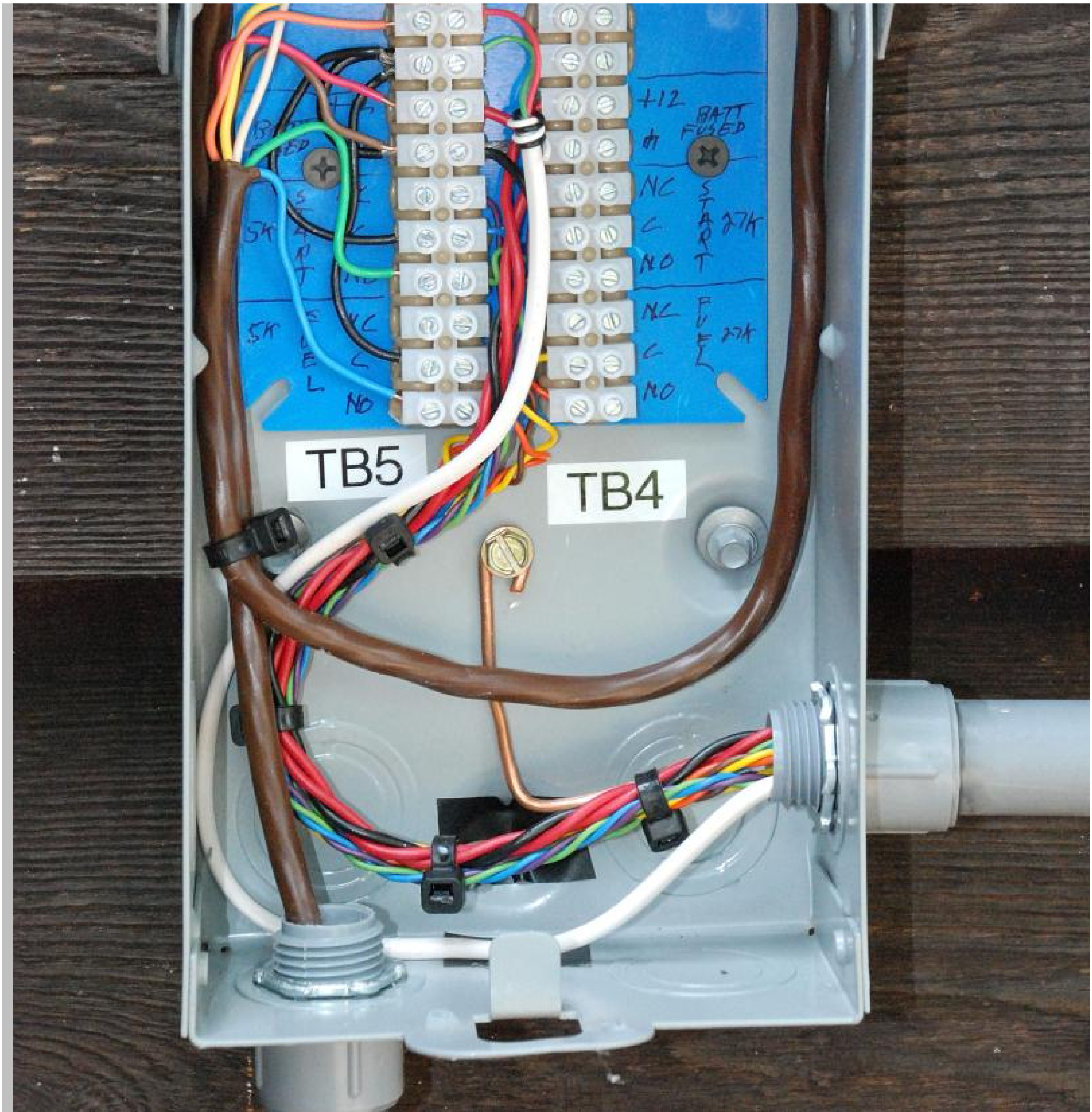
You can see the connectors mounted just above the output connections L3 and L7 of the ATS.

The control panel for the ATS. Pretty simple, huh? Well, yes, but... like all good computer logic, it can get into a snit and get really screwed up. It does not like electrical noise on the control lines, and it is happier with a back up battery instead of getting power from the genset battery. But, when it works, it works really well. I just wish

some of the operating parameters were adjustable, but everything's burned into the PROM inside the control chip.



This is the conduit that carries the control and data lines from the ATS to the house and the genset control switchbox. I tried to keep control lines away from AC power lines as much as possible.



I took a small fusebox and removed the guts to obtain a weather tight empty box in which to place a pair of terminal strips for the genset control connections. It was cheaper to buy the fuse box and gut it than to buy a plain empty box. Go figure!

The brown cable running to TB5 comes from the 5 KW Onan genset. A similar cable from the 27 KW genset will connect to the right side terminal strip TB4.

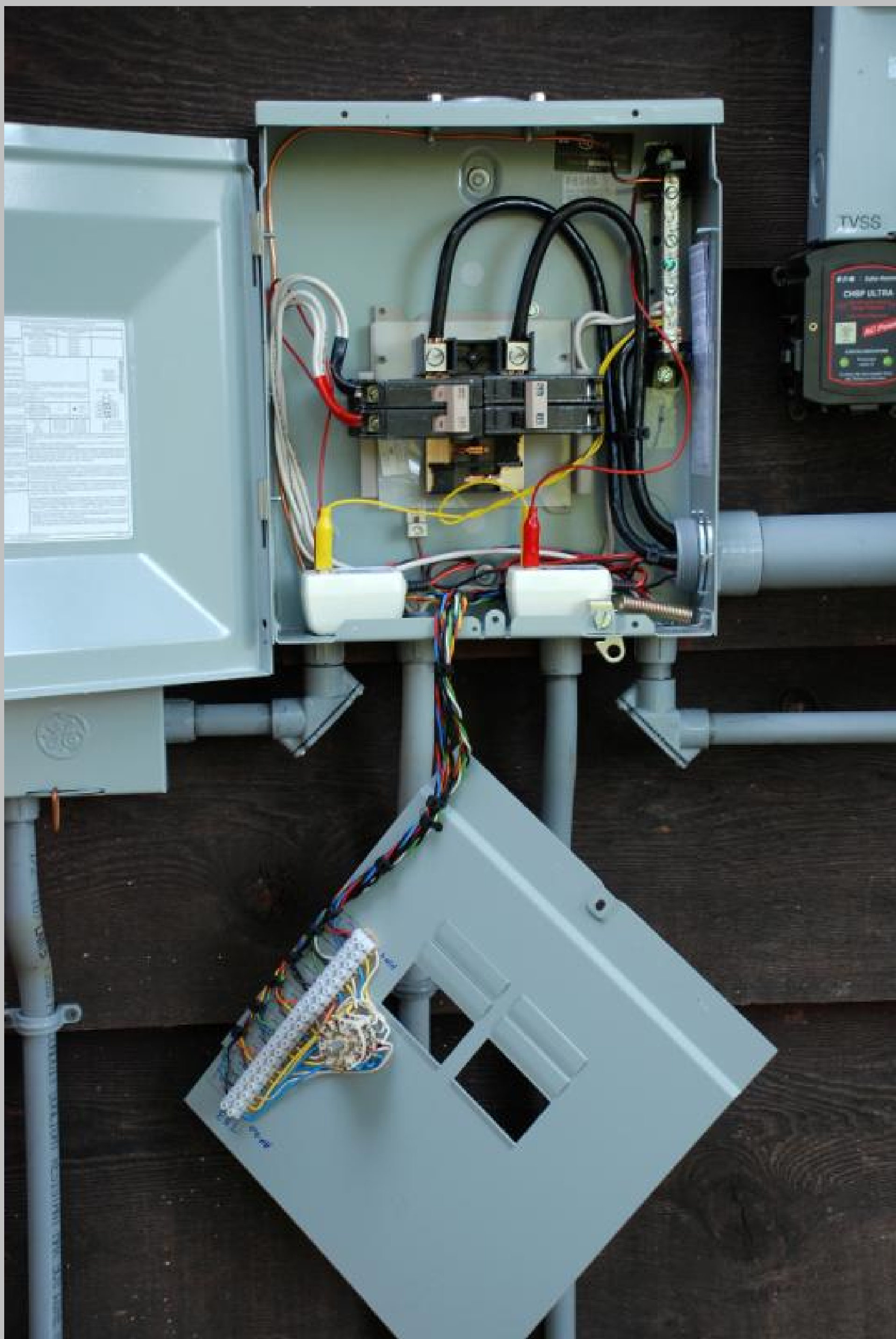
The twisted multi-colored wires go to the next cabinet to the right of this one. That cabinet houses the AC circuit breakers and the rotary switch that transfers the actual engine control signals from the ATS control panel to the selected genset.

See the white cable? It runs up to the attic where it controls a small relay that shuts down the house 5 ton air conditioning compressor when the 5 KW genset is running. This necessary since the little 5 KW genset cannot handle the A/C system. The 27 KW genset will run everything, of course, so the relay is not used when the 27 KW genset is on line.

This cabinet houses a pair of circuit breakers. They are fed "in reverse" so that power from both gensets flows through the appropriate breaker and onto the buss back to the emergency power input terminals of the ATS. Needless to say, both breakers should never be turned on when either genset is running or the Magic Smoke will surely escape from one of the generators! This cabinet will be locked and only opened by Bonnie or I when it is necessary to transfer from one genset to the other.

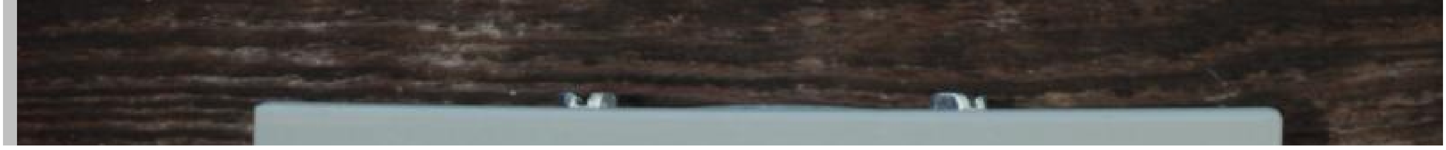
Besides "throwing over" the AC power breakers when changing gensets, it is necessary to transfer the control lines as well. The "chicken head knob" rotary switch accomplishes that task.

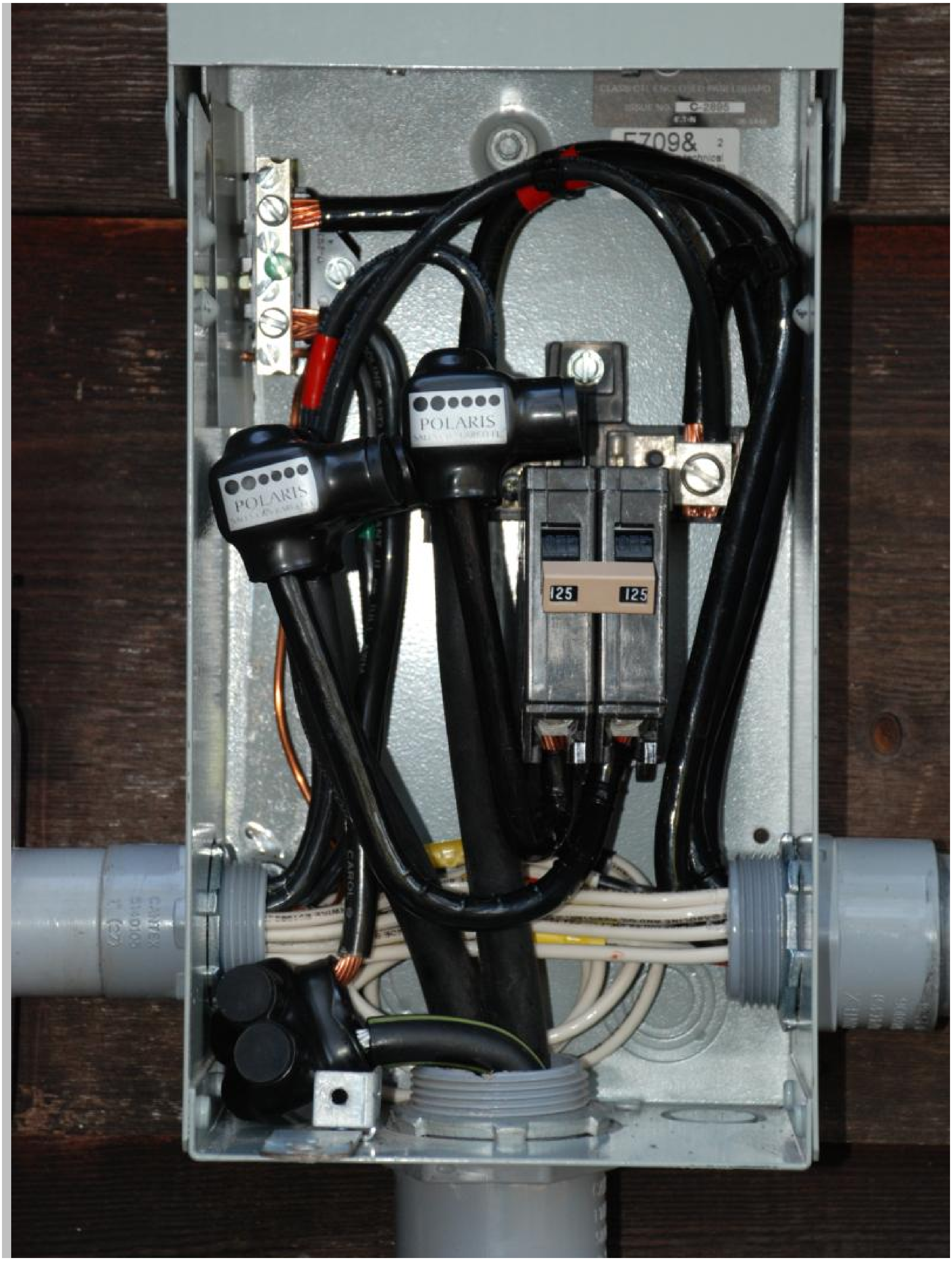
Looking behind the panel during construction, you can see the rotary switch used to transfer the control lines between the two generators. The rotary switch terminates on TB3 which is mounted on the rear of the dead front panel. The coiled up wires were threaded through the small conduit and go back to the ATS cabinet on the green plug on the control panel, and also go to TB4 and TB5 to connect to the gensets.



Looking into the Generator Control Panel cabinet with the front cover in the maintenance position.

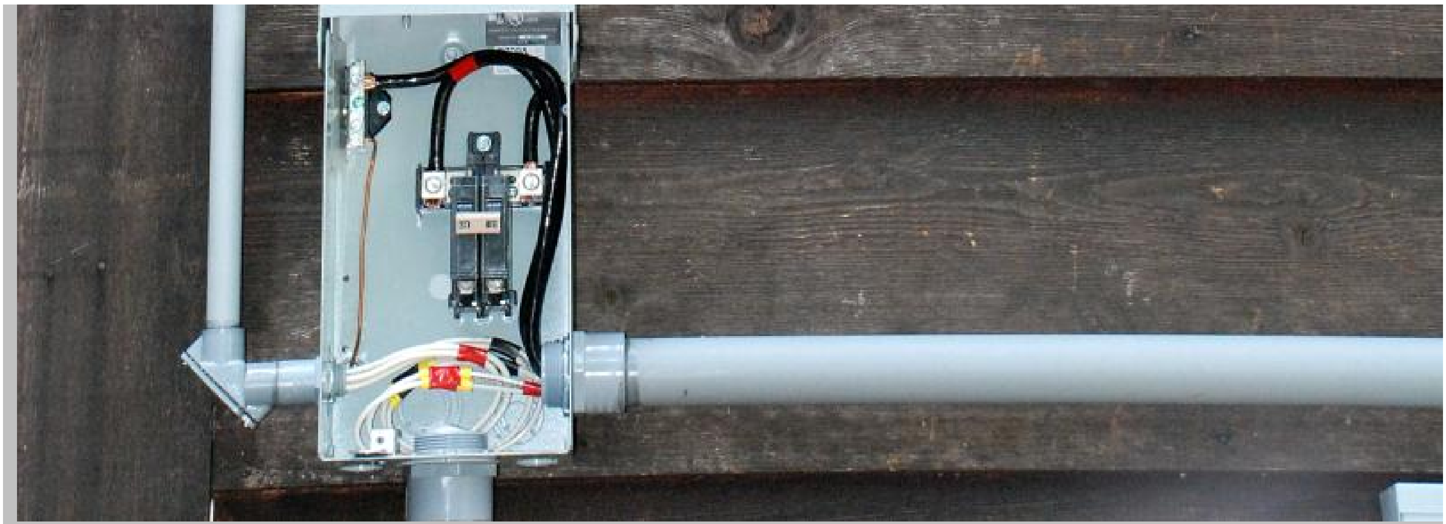
Note that the circuit breakers are in the 5 KW GENSET position. The AC feed wires from the 27 KW genset have not yet been run into the cabinet for connection to the breakers on the right side of the cabinet. The two wall-wart transformers in the bottom of the cabinet are for monitoring the AC power output of the two generators.




POLARIS
POLARIS
125
125

The wires going into the lower conduit are for the underground feeder running to the new ham shack/art studio we are constructing. This is the 125 Ampere main breaker for that feeder.

The white wires are connected to a reactance compensating capacitor that is connected across the utility power feed.

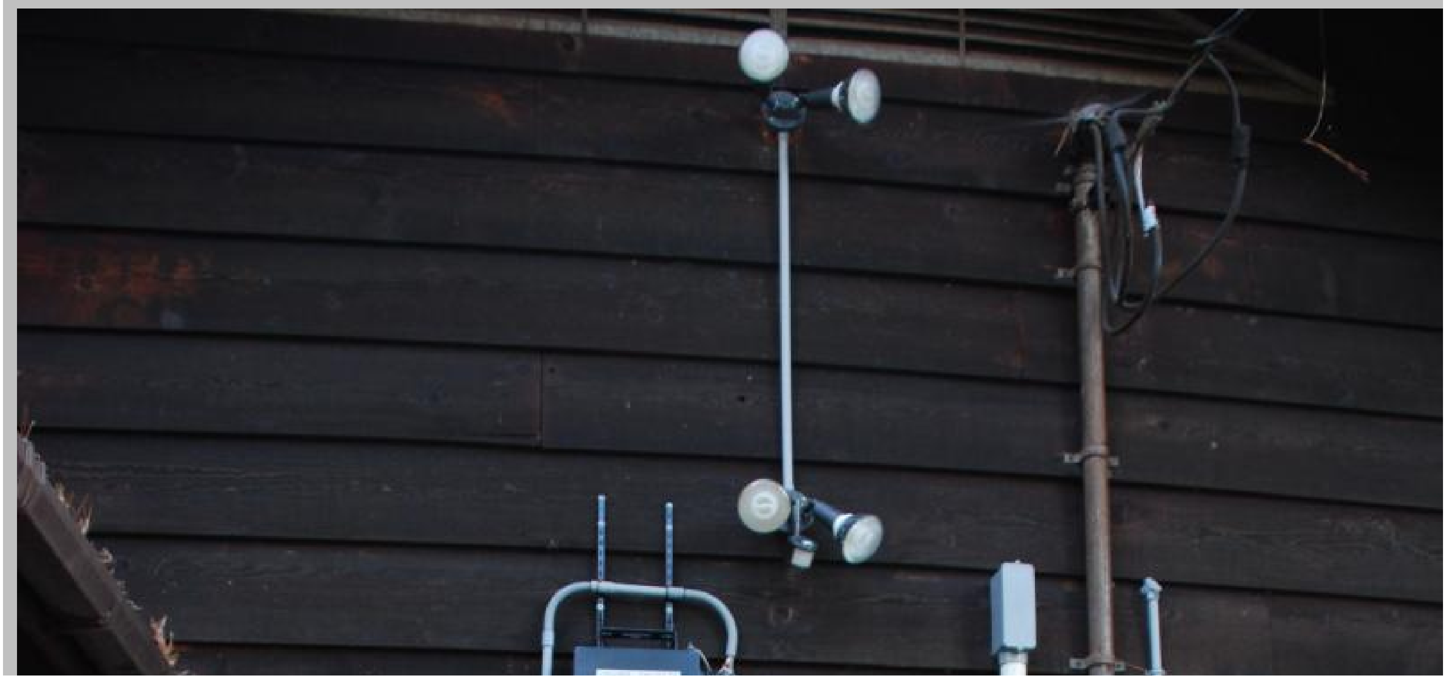


One of the "fun" things about living in the country is that you really get to play with your generator and electrical systems a whole lot!

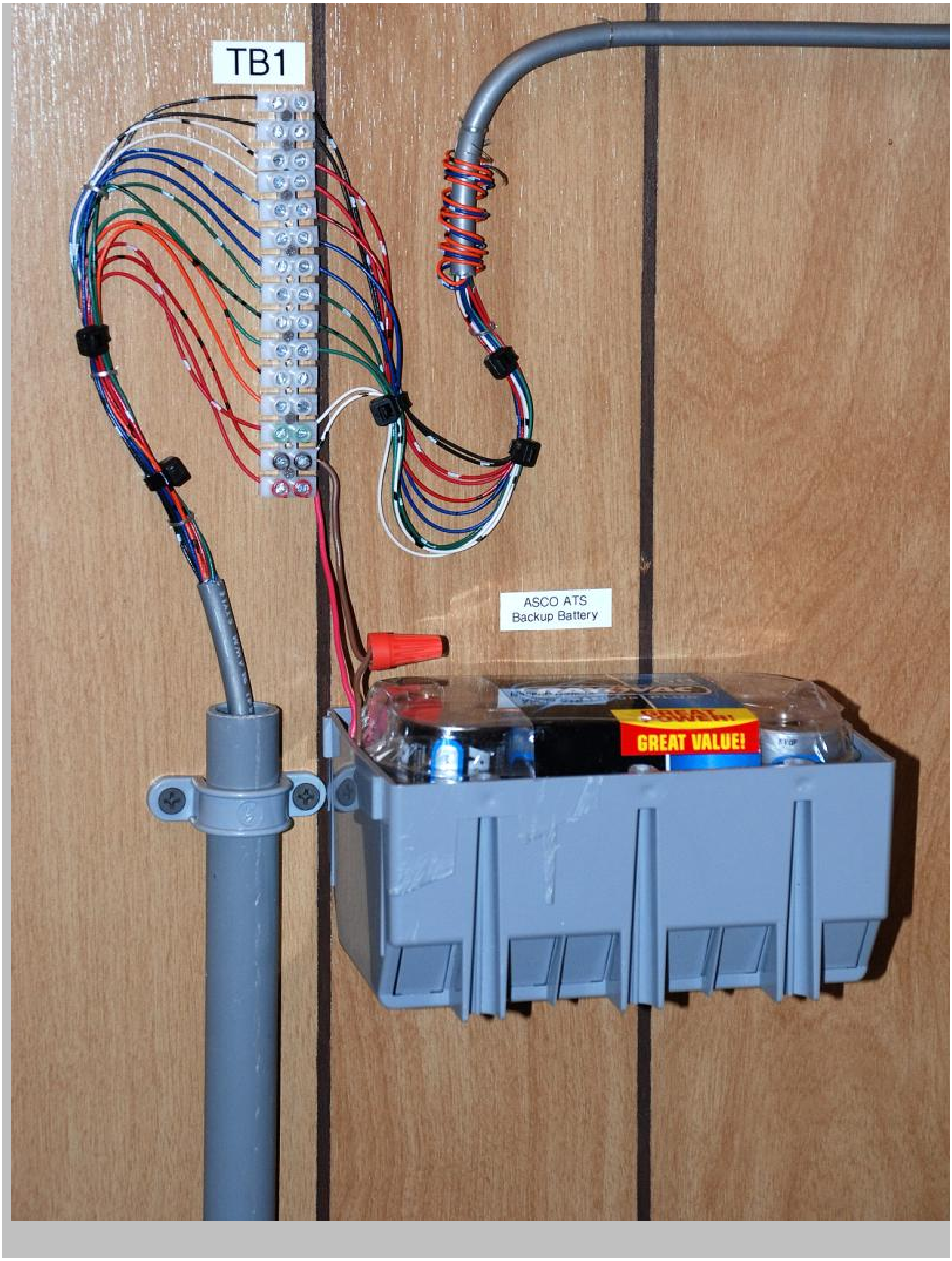
One of the more annoying happenings is that we have had a great number of minor power bumps, burps and bobbles that greatly upset some of the in house electronics, including crashing several of the UPS units from time to time. Although the main power line on the road seems to hold up pretty well for voltage stability, I noticed that every time a motor driven appliance started up - especially the central A/C - the lights would dim a bit.

I did some checking, and I suspect that the power transformer feeding the house does not have a high surge current capability. I suspected that the inductive reactance of the motors was causing a high reactive current to flow, causing the voltage drop. Temporarily connecting a big capacitor across the line seemed to help, so back to the Junque Box I went. I found a big power factor correction capacitor, rated at 5 KVAR @ 240 volts. That should do the trick!

I mounted it up high on the outside wall where no one can get at it (The terminals were not covered with insulation when this picture was taken) and connected it through appropriate fuses back to the incoming feed from the local utility. Since the capacitor went on line, the incidence of power line disturbances has decreased to almost zero. The only light dimming I now see is when the main A/C cranks up, but it is greatly reduced from what I observed before.



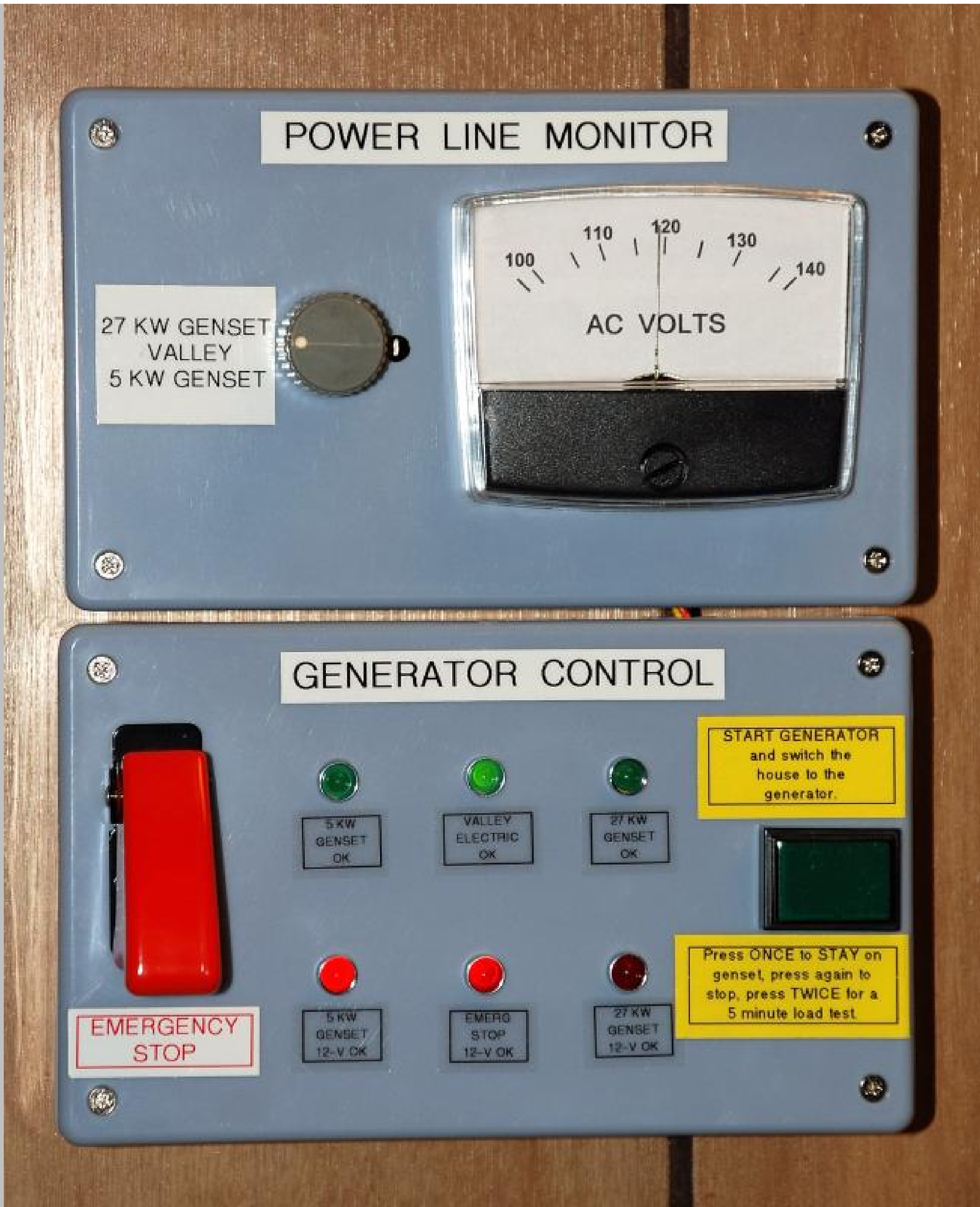
Finally! All complete, after a lot of time, effort and money. But, the results are worth it. Everything is automatic and switches to the genset within 35 seconds after a power failure.


TB1
ASCO ATS
Backup Battery
GREAT VALUE!

The control and monitor cable from the ATS comes into the house through the wall and terminates at terminal strip TB1. Also mounted on the wall is a 12 volt "D" cell battery pack that serves as the backup battery for the ASCO ATS. As long as power is supplied by either the local utility or the selected generator, the battery sees no current drain. Should the utility power go away and neither genset start, the battery will have to supply a 20 mA load. It will last about a week under that current drain.

The battery is needed because the design of the ATS control is such that in the event of a utility power failure, it will attempt to start the selected genset three times over a 30 second period. If the genset fails to start, the control panel will lock out the fuel supply and ignition system on the genset and then "go to sleep" until you manually reset the control panel. If no external battery is present, the control panel simply "dies" and will not start the genset even if you reset the panel.

One thing this panel really needs is a remote control connection that will allow you to see the status lamps and press the control panel reset button remotely. Due to the construction of the key panel (membrane keys and plastic strip wiring) it is difficult to kludge on external connections. Not to mention that: a) the unit is still under warranty, and, b) the panel costs $385.00 to replace if I screw it up.



I mounted a small control and expanded scale AC voltmeter on the wall inside the house.

The red lights tell me that 12 volts DC control power is available from both genset batteries, and that there is 12 volts available to trigger the emergency genset shutdown relay. The shutdown relay is controlled by the guarded toggle switch under the red cover.

The green lights are AC power samples generated by the Radio Shack wall-wart transformers. These LED's indicate that there is AC power available from the local utility or the generators.

The dark green square push button switch is used to initiate a genset load test or to lock the house onto the genset is needed during a poor utility power situation.

The expanded scale voltmeter lets me monitor the AC power coming from the local power company, or either of the two emergency generators

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Now that the generators were installed, it was necessary to have a reliable fuel supply on hand for them. Because storing large quantities of gasoline or Diesel fuel would be difficult, and there are no natural gas lines in the area, it was necessary to use propane as the fuel source. Propane is ideal, as it stores indefinitely with no degradation or aging problems. Internal combustion engines like propane, and give very little trouble when using it as a fuel.

Since there was no possible way the gas line in the house would be able to supply the quantity of fuel needed to operate the engine in the genset, I decided to install a brand new underground gas line between the propane tanks and the generator. This was done while the trenches for the water lines and electric feeder were being dug. This view shows the service riser curving out of the ground by the genset. It is connected to the yellow pipe you can see partially buried in the trench.

Around the side of the house goes the new gas line.

It continues around the back of the house.

Towards the propane tanks.

Until it finally connects to the tanks.

A manifold system allows either or both tanks to feed both the underground gas lines. The line on the right side goes to the gas service in the house, and the line on the left goes to the generator. There is a shut off valve on each line, and a shut off valve on each tank. Each tank has a separate 10 PSI regulator feeding the manifold. There is a pressure gauge on the manifold to tell me things are working correctly. The tank regulators are set so that the small tank will be used first, then fuel from the larger tank. There is a 10 PSI to 13" WC regulator at the house, and another at the genset.

This is the regulator and pressure gauge at the generator end of the gas line. Note the numerous parts and pieces of pipe used between the regulator and the genset fuel fitting. this is what happens when you live in a small town and the hardware stores pipe threading machine is broken. You ":make do" what what you can find on the shelf!

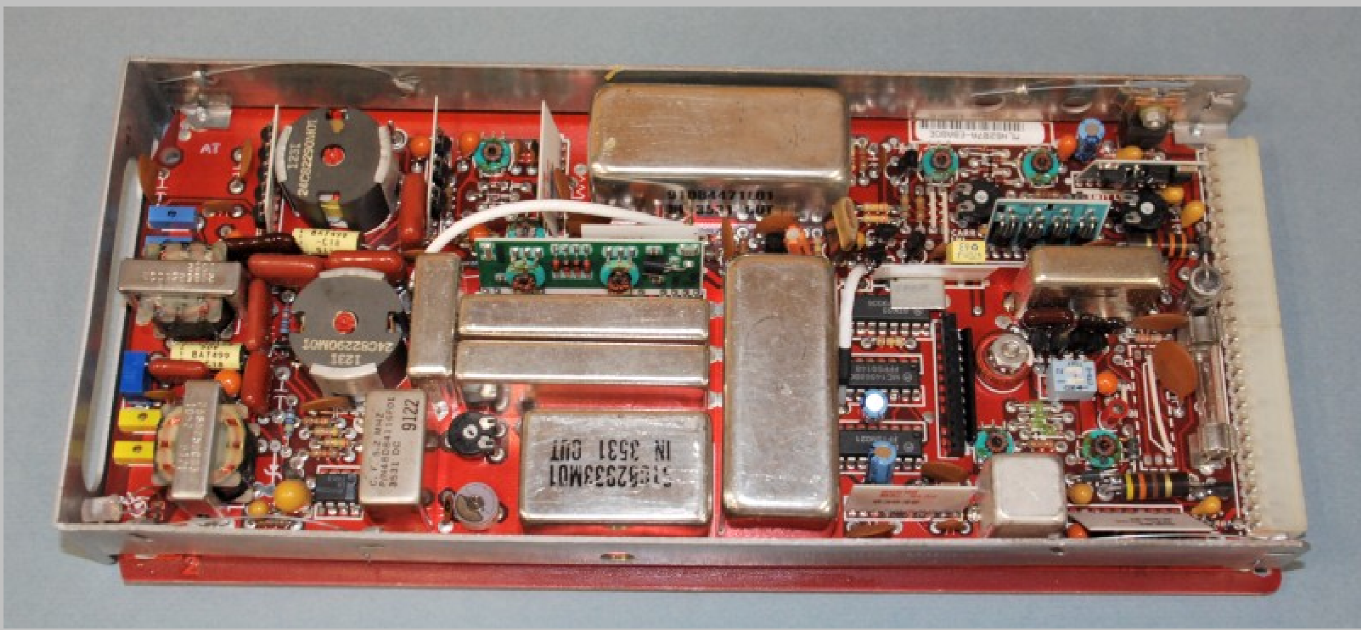
73, Ralph W5JGV

[Home]

Using the Motorola StarPlex Channel Modem on 600 Meters

by W5JGV

September 4, 2010



The Motorola StarPlex Channel Modem, MLN6287A

Click HERE to download the manual for the modem

Click HERE to download the schematic diagram and parts layout for the modem.

The technical data is somewhat incomplete, so if you come across any additional data about these modems, please let me know so that I can add it to this web page. Thanks!

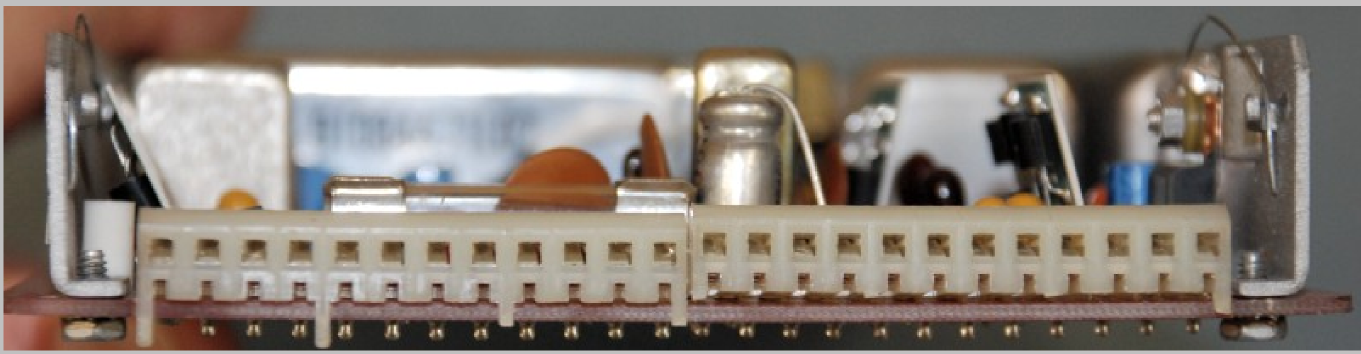
OVERVIEW

The Motorola StarPlex Channel Modem was designed to be bused in wired or radio carrier telephony systems. Each modem contains a transmitter and receiver. The transmitter section accepts an audio signal in the range of 300 - 3600 Hz. The transmitter then generates either a single sideband suppressed carrier signal on one of 614 discrete channel frequencies. The channel baseband carrier frequency is set by the use of a programming plug, which may have either a 10 position DIP switch on a plug-in SIP style card, (MLN6406A) or a "scratch-off" ceramic SIP card, (MLN6309A). Setting the appropriate DIP switches or scratching out conductive areas on the ceramic card will send -15 volts to the pins of the divider stages in the frequency synthesizer chain in the modem to select the carrier frequency. Each modem may be set to any one of the 614 channel frequencies by the use of the programming plug.

For use on 600 Meters, we will be concerned with two channel frequencies, 492 and 508 KHz. In this frequency band, the modem generates an upper sideband suppressed carrier output. The ARRL Experimental Project on 600 Meters has assigned QRSS and CW operations in the low end of the 495 - 510 KHz band, and PSK, MSK, and CW in the upper part of the band.

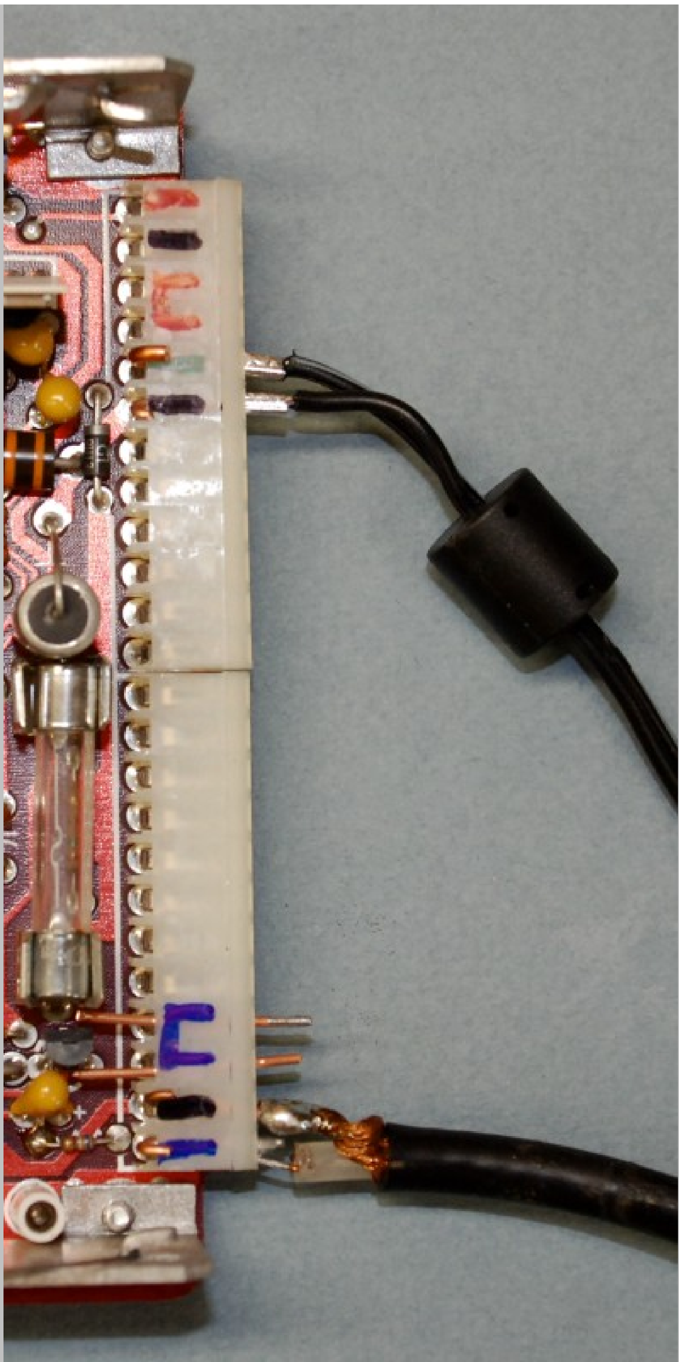
Note that the modems I am working with are the Motorola StarPlex series of channel modems, type MLN6287A, and not the StarPoint MLN6625A units. The MLN6625A are more available on eBay and elsewhere. So far I have been unable to locate any information at all about the 6625's, so I do not know if they are usable on 600 Meters. I suspect that they generate carriers in the 5 MHz range, instead of lower baseband carriers as do the 6287's.

CONNECTIONS and POWER



Looking at the card edge connector on the modem. Pin 1 is to the right side of the connector, and pin 24 is to the left side.

Pin numbers are shown on the solder side of the circuit board.



In this photo,pin 1 is at the top and pin 24 is at the bottom.

This modem is set up for receive only, so there are no connections to the RF output pins.

The most commonly used pin connections from top to bottom are:

Pin 1 (red) - TX RF Output Hot, Pin 2 (black) - TX RF Output Shield/chassis ground,

Pins 3 & 4 (red) - TX Audio Input, balanced and isolated from ground, 600 Ohm nominal impedance.

Pin 5 (green) -24 Volts DC, Pin 6 (black), -24 Volt DC return/chassis ground, NOTE: this is a POSITIVE GROUND unit.

Pins 21 & 22 (blue) - Receiver Audio Output, balanced and isolated from ground, 600 Ohm nominal impedance. NOTE: RX AF Gain is adjusted by the small pot that is visible through the front panel.

Pin 23 (black) - Receiver RF Input Shield/chassis ground, Pin 24 (blue) - Receiver RF Input Hot.

The modem requires a positive grounded, negative 24 volt power supply. The allowable hum and ripple is 300 millivolts. The tolerance of the supply voltage is + or - 10 percent. The modem draws about 150 milliamperes.

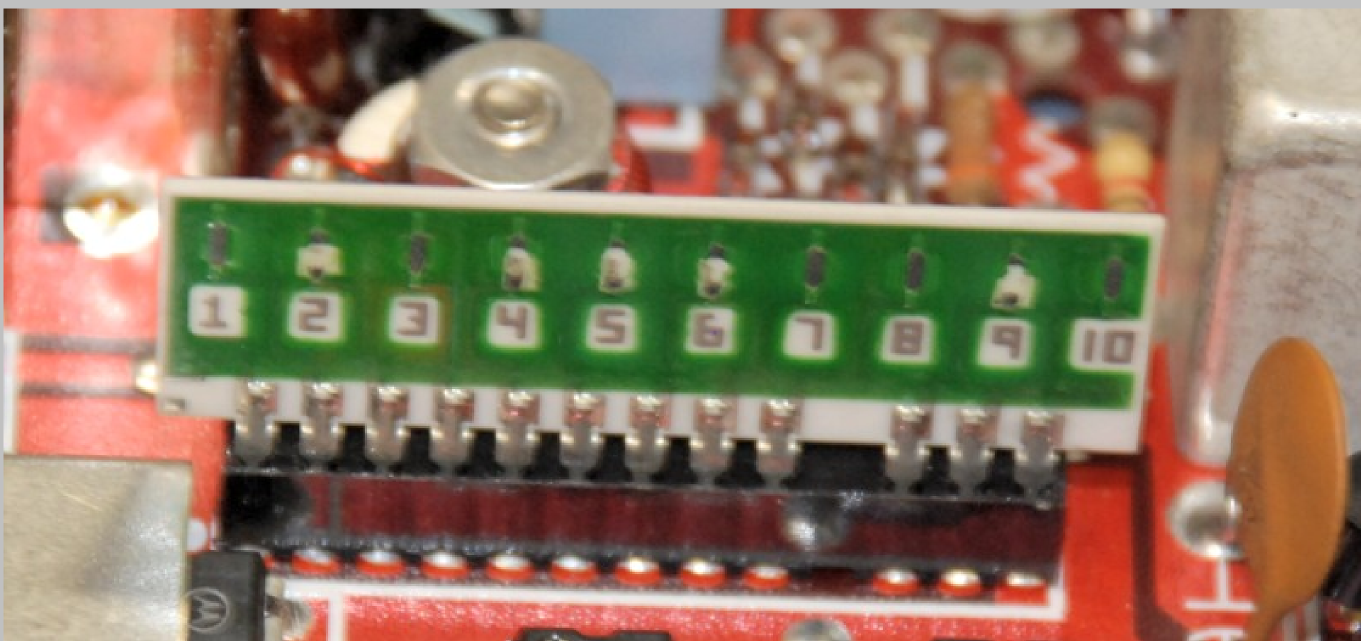
The chassis of the modem is connected to the positive side of the power supply, therefore the positive side of the supply will be grounded.

A suitable power supply may be made from a voltage regulated "wall-wart" power supply. I have found several of these at second hand stores that were previously used with HP printers. Just remember that the modem requires a POSITIVE grounded power source.

CARRIER CHANNEL PROGRAMMING

If you are lucky, your modem has one of these handy programming plug assemblies already installed. If not, you can make one or just use some thin wires to make the necessary jumpers.

This one is programmed to put the modem on a channel baseband frequency of 508.000 KHz.



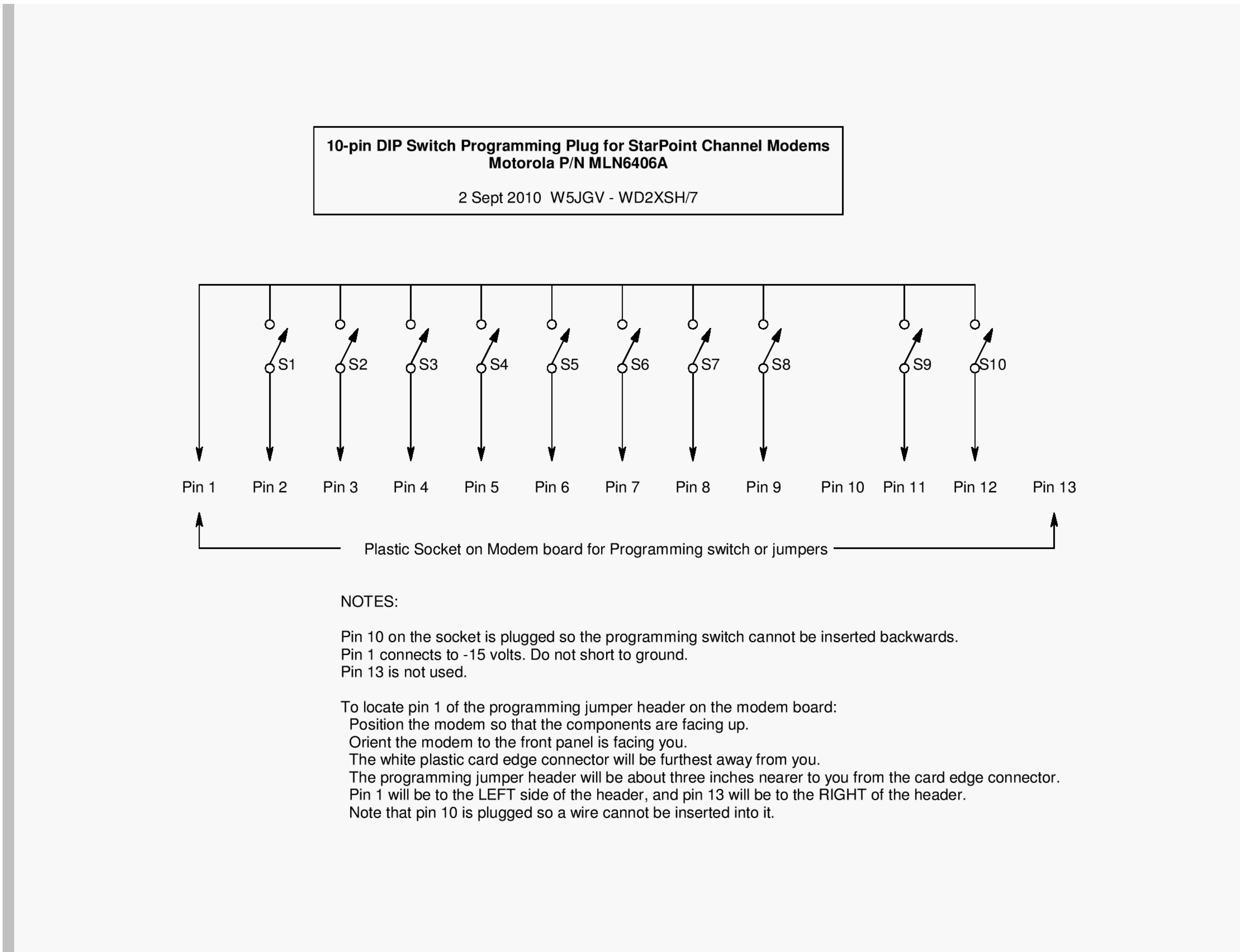
This is an example of a "scratch-off" programming plug, MLN6309A.

Note that "switches" 2, 4, 5, 6, and 9 have been scratched open, so those switches are off. This programs the modem to a baseband carrier frequency of 148.000 KHz.

The chart below shows the DIP Switch Settings for Motorola StarPlex Channel Modem when you are using the Motorola Programming Plug MLN6406A (with switches.) If you make your own programming plug using jumper wires, please use the data in the last column to the right of the page to make your programming jumpers.

Note that the minimum audio frequency the modem will accept is 300 Hz, and the maximum audio frequency is 3600 Hz. Frequencies above and below these limits will be blocked by the modem's internal band pass filters. This means that there is a 1300 Hz gap between the top of one channel and the bottom of the next upper channel.

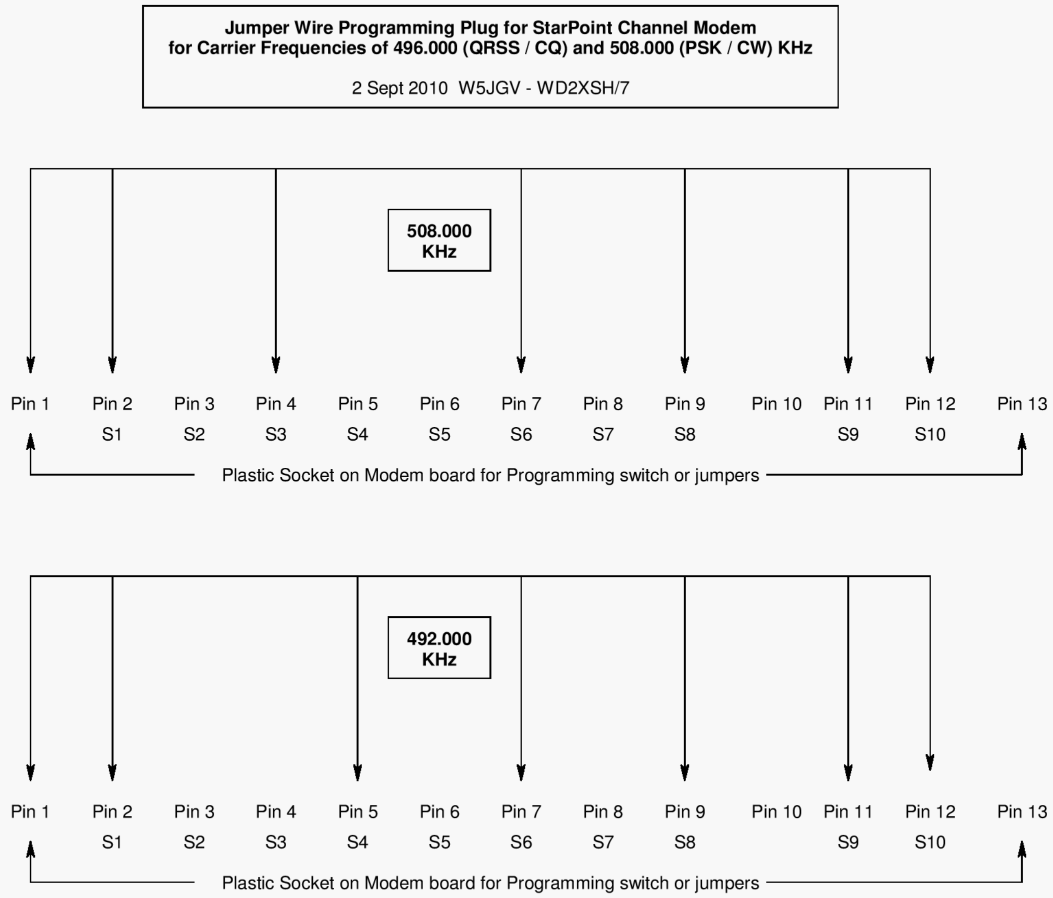
CARRIER FREQUENCY	300 HZ IN = RF Output of	3600 HZ IN = RF Output of	SWITCHES OFF = DOWN	SWITCHES ON = UP	JUMPER WIRES IN HEADER
492 KHz	492.300 KHz	495.600 KHz	2-4-5-7	1-3-6-8-9-10	1-2-5-7-9-11-12
496 KHz	496.300 KHz	499.600 KHz	4-5-7	1-2-6-8-9-10	1-3-7-9-11-12
500 KHz	500.300 KHz	503.600 KHz	1-2-3-5-7	4-6-8-9-10	1-5-9-11-12
504 KHz	504.300 KHz	507.600 KHz	1-3-5-7	2-4-6-8-9-10	1-3-5-7-11-12
508 KHz	508.300 KHz	511.600 KHz	2-3-5-7	1-4-6-8-9-10	1-2-4-7-9-11-12
518 KHz	518.300 KHz	521.600 KHz	1-3-5-7-9	2-4-6-8-10	1-3-4-7-9-11
148 KHz	148.300 KHz	151.600 KHz	2-4-5-6-7-9	1-3-9-10	1-4-11-11



Please Right-click on the picture above to save it as a high resolution GIF file.

The diagram above is the wiring diagram for the Motorola MLN6406A Programming Plug using the 10 position DIP switch. If you don't have one of these handy programming units, you may make a simple wire jumper setup as shown in the next diagram. 24 or 26 AWG wire should fit into the header socket nicely. This will allow you to set the channel frequency of the modem.

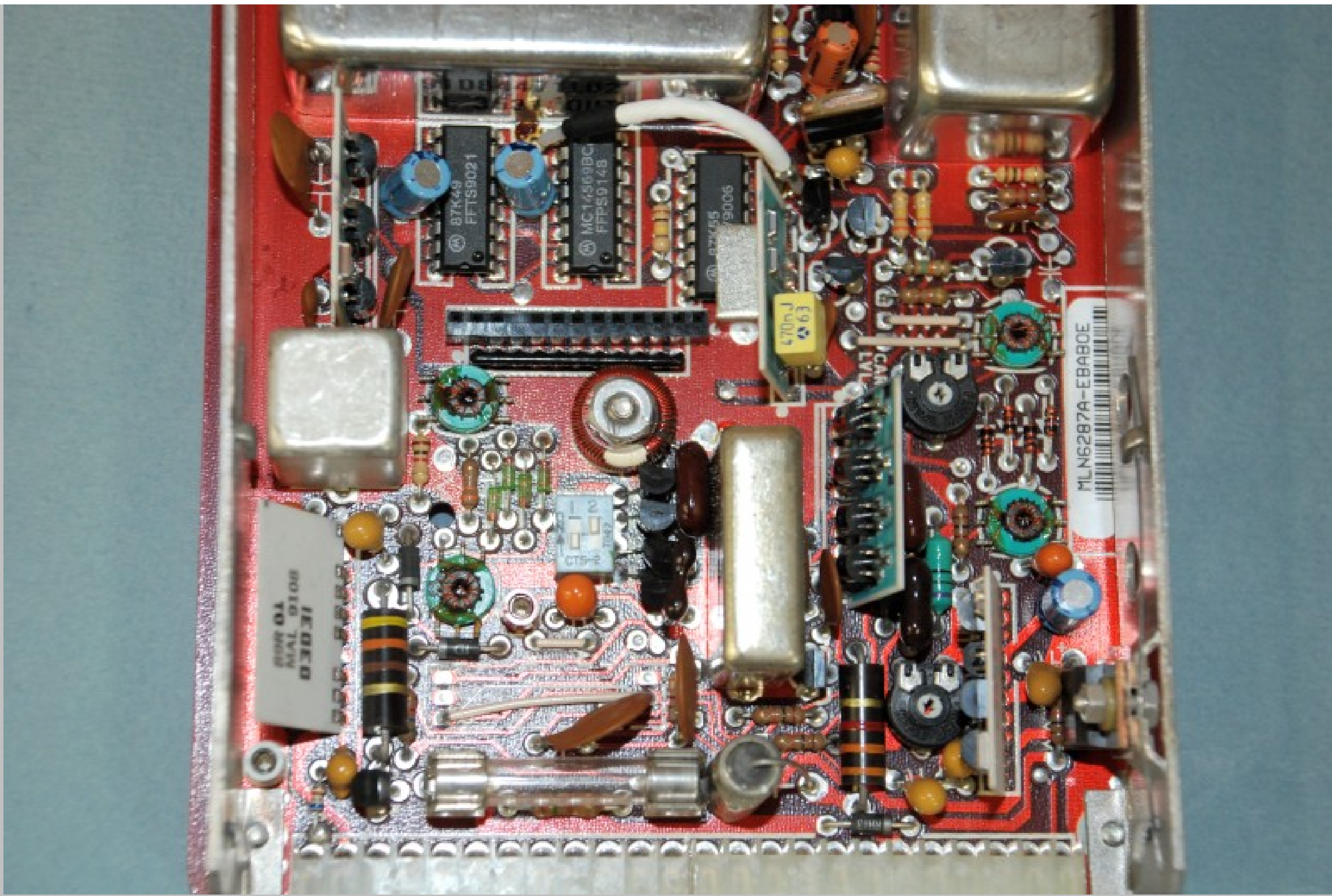
Please note that the header PIN numbers DO NOT correspond to the SWITCH numbers!



Please Right-click on the picture above to save it as a high resolution GIF file.

This diagram shows the jumper arrangement you will need to program the modem to the two most common parts of the 600 Meter band for the ARRL Experimental Project. Note that there is only one switch/wire jumper difference between the two frequencies. You can use a SPDT switch to rapidly QSY between the two channels if you wish, however, besides switching these two jumper wires, you will also have to reset the RANGE SWITCH on the modem. (See next photo.) Since the jumper wires carry 15 volts DC, no shielded wire is necessary. The required switch may be mounted on the front panel of the modem in place of the ALARM LED, since the LED is not required for TX or RX operation.

Please note that the header PIN numbers DO NOT correspond to the SWITCH numbers!



This photo shows the black plastic programing plug socket. It is seen near the top left of the photo. Midway down the picture, below the programming plug socket and the glass fuse, you will see a small, 2 position DIP switch, that is blue in color. Motorola calls this switch the RANGE SWITCH.

This switch is used to select several varicap diodes which act as tuning capacitors in the low pass filter loop in the frequency synthesizer. Depending on the baseband channel frequency you have selected, the settings of this switch will need to be changed. If you set the switch to the wrong setting, you will get little or no RF output from the modem.

The DIP switch settings I have found that work on the modems I have are: for 492 KHz QRSS, switches 1 and 2 ON. For 508 KHz CW/PSK, switches 1 OFF, and 2 ON. Try different switch combinations if necessary, and use the one that gives the highest RF output.

TRANSMITTING WITH THE MODEM

Here is an example of the first-time setup of the modem for operation on 495.028 and 508.800 KHz. These are the assigned frequencies for WD2XSH/6.

1 - Program the modem for the correct baseband channel frequency by using the programming plug or jumper wires and set the RANGE switch to the correct setting.

For the PSK/CW channel frequency of 508.800, you will need switches 2, 3, 5 & 7 set OFF, and all the rest of the switches set ON. This will set the modem to a channel carrier frequency of 508.000 KHz.

2 - Connect a source of DC power to the modem, -24 volts DC to pin 5 and ground to pin 6.

3 - Take the RF signal from the modem on pin 1 (hot) and pin 1 (shield ground.)

4 - With no audio applied to the input of the modem, monitor the RF output from the modem with an oscilloscope.

5 - Set the XMIT LVL pot full clockwise (maximum gain.)

6 -Adjust the CARR LVL pot for minimum carrier level as seen on the oscilloscope.

7 - Connect an audio signal to the modem audio input on pins 3 and 4.

To generate a CW signal on 508.800 KHz, you will need to send the modem an audio tone of 800 Hz. This will cause the modem to generate an USB carrier on 508.800 KHz. To generate the CW signal, all you do is key the audio signal going to the input of the modem. For PSK, you set the audio output of the PSK program to frequency of 800 Hz and send that to the modem.

For the QRSS channel frequency of 495.028, you will need switches 2, 4, 5 & 7 set OFF, and all the rest of the switches set ON. This will set the modem to a channel carrier frequency of 492.000 KHz. To generate the QRSS signal on 495.028, you will need to send the modem an audio tone of 3028 Hz, and then key the audio signal going to the input of the modem. This will cause the modem to generate an USB signal on 495.028 KHz.

8 - Starting at zero level, slowly increase the audio signal until the RF output as seen on the oscilloscope stops increasing. That is the maximum peak audio level you can send to the modem without distorting the RF output. This is important for PSK operation, as excessive audio input will severely "flat-top" the peaks of the PSK signal.

Things to be aware of:

The impedance of the RF output of the modem transmitter is high impedance. Use a short length of low capacity coaxial cable to connect the modem to your amplifier. The longer the interconnecting cable, the lower the available signal at the amplifier end of the cable. You may need to use a cathode or emitter follower amplifier to obtain a sufficiently low impedance drive source for your amplifier.

Note that the maximum usable gain setting of the XMIT LVL pot will depend on the load impedance seen by the modem RF output terminals. This, in turn, will affect the maximum audio signal you can send to the modem without distortion. In other words, the load impedance, XMIT LVL and audio input level all interact with each other. I suggest keeping your oscilloscope connected to the RF output until you have everything working smoothly. This is particularly important for any linear mode, such as PSK or SSB.

By using various settings of the channel programming switches, you can cover the entire band from 495 to 510 KHz - almost. One "Gotcha!!" is that there is a guard band between the channels. That means there is a series of gaps across the band where the modem will not output a carrier due to the internal filters. It may be possible to be remove them, but I have not looked at that yet.

For example, with the modem programmed for 492.000 KHz, you can use an audio tone from 300 to 3600 Hz to generate an RF output from 492.300 to 495.600. Changing the programming switches to a carrier frequency of 496.000 KHz (the next higher channel) results in an RF output of 496.300 to 499.600. In this case, the gap runs from 495.600 to 496.300.

It is possible to increase the audio signal into the modem above 3600 Hz and below 300 Hz to force the modem to output a signal in the guard band, but if you increase the audio drive too much, the RF output will collapse as the internal amplifiers in the modem clip and distort. Be sure to look at the RF output with a scope as you tweak the audio drive and the output amplifier gain adjustment pot.

Be aware that the modem "leaks" a little bit of carrier signal even with no input audio signal. The carrier suppression is pretty good, -55 dB or more, but you will still hear it on your RX when your key is up if the power amp is on and running in linear mode. This is usually not a problem unless you are trying to listen for a signal close in frequency to your carrier. In that case, either turn off the amplifier during RX or bias the amp so that it is just beyond plate current cutoff with no drive. OR power off the modem during RX. That will not work for break-in keying though since the modem takes a couple of seconds to power back up.

RECEIVING WITH THE MODEM

Although the setup for using these modems to transmit is pretty straightforward nothing was said so far about the possibility of using these modems to receive with.

Because my earlier use of these modems several years ago was to generate a SSB signal on 166.5 KHz for my Part 5 beacon transmitter (WC2XSR/13,) I had never planned on using the modem as a receiver. When I shifted the modems to the 600 Meter band for QRSS and CW/PSK31 operation, the same mind-set took hold, and I completely ignored the receive side of the modem. I received an email from Pat, W5THT - WD2XSH/6, about receivers for 600 Meters, he queried me about the possibility of using the receive side of the modems on 600 meters. That thought intrigued me, and I decided to run some tests on the modem receiver to see just how good or bad it actually is.

I referred to the modem test procedure, and determined that the RF carrier sensitivity was supposed to be -55 dBm @ 75 Ohms. That is rather poor for the front end of a receiver. Nevertheless, that spec was for the receiver in normal operation, not weak signal conditions. Testing was in order to determine whether or not the receiver was really that deaf.

My test setup consisted of my AIM-4170 acting as a signal generator. The signal went through an 80 dB attenuator, which is switchable in 1 dB steps. From the attenuator, the signal was split and went to one of my HP-3586 SLM's, which would act as the reference receiver. The signal also went to the input of the modem receiver. The output of the HP-3586 and the modem receiver each went to separate ARGO displays so I could compare signals. The bandwidth of the HP-3586 was set for 3100 Hz, which closely matched the bandwidth of the modem's receiver.

The Minimum Detectable Signals (MDS) for faint but solid ARGO traces were:

HP-3586 -116 dBm

Modem -108 dBm

I was surprised, to say the least. That MDS was down below the noise floor on 600 Meters just about any time of year. It looks like the modem receiver should be usable on 600 meters.

Some Things To Be Aware Of if you use the modem as a receiver:

- The modem has no front-end static or overload protection. It would be a very good idea to use some back-to-back protection diodes across the RF input.

- As with most LF and VLF receivers, common mode noise can be a problem. Using a small isolation transformer to break the shield of the coax from the antenna will help greatly to eliminate the noise. The transformer will also protect the front-end of the receiver from static discharges. A suitable isolation transformer may be made by scavenging a dual winding ferrite core common mode RF mains choke from an old computer power supply.

- The RF front-end of the modem receiver has no RF tuning or band pass filter. It pretty much accepts stuff from DC to light. There is an internal band pass filter, but that is after the first mixer in the receiver. It would be a very good idea to add a preselector in front of the receiver. That being said, the unwanted spur and image problem seems to be almost non-existent. Signals about 400 KHz away from the desired frequency had to be increased up to almost -30 dBm in strength, or about 78 dB stronger than the desired signal before spurs started showing up in the ARGO display, and that was with no front-end tuning or filters.

- The front-end of the modem receiver is speced at 75 Ohms. When it was in use, the 75-Ohm termination was really in the backplane of the card cage that the modem was plugged into. The receiver input is quite different. According to my AIM-4170 the impedance of the receiver input looks like 3000 Ohms. Basically, an open circuit. This means that a front-end RF tuner with an impedance step-up to the receiver input would be a suitable addition for both sensitivity and rejection of unwanted signals. That very high front-end impedance also makes the unit very sensitive to static and lightning impulses. Use some sort of lightning suppression on the input, as noted earlier.

- The audio output from the receiver is pretty low at the MDS point. Even with a signal level set to 30 dB higher than the MDS level, the audio signal from the receiver barely tickled the green level indicator bar in ARGO, even though I had the Line Input gain slider in the Volume Control settings box on my computer set for maximum gain. A small, low noise, audio preamplifier might give some weak signal improvement, depending on your computer sound card.

- Remember that this receiver will generate an output audio signal at a frequency that is the difference between its base carrier frequency and the incoming RF signal. In other words, you cannot change the pitch of the CW or PSK signal you are listening to. What you hear is what you get. You have to use your brain or a computer program to sort it out.

General Q & A

Q - About the plastic 24 pin connector to plug the board into the rack, did you unsolder it and replace it? If so did you just wire to it or find another plug?

A - On one modem, I found that the motherboard power plug on an old 386 AT motherboard was exactly the right pin size and spacing, so I salvaged that and used it. For the other one, I simply inserted some short lengths of 14 gauge (I think) copper wire into the connector holes and used some hot melt glue and a strip of plastic to make a quick-and-dirty connector. You only need a few pins anyway. -24 volts, ground, RF out and chassis ground, and two audio input wires.

Q - What about the audio, can I ground one side of the audio going to the modem? What about the audio output from the modem receiver? Does "4-wire T" mean I have to use balanced 600 ohms only?

A - Although the audio input is 600 ohms balanced, it is transformer coupled, so either one of the audio input lines can be grounded if you use single ended audio input.

Q - What is E&M Signaling?

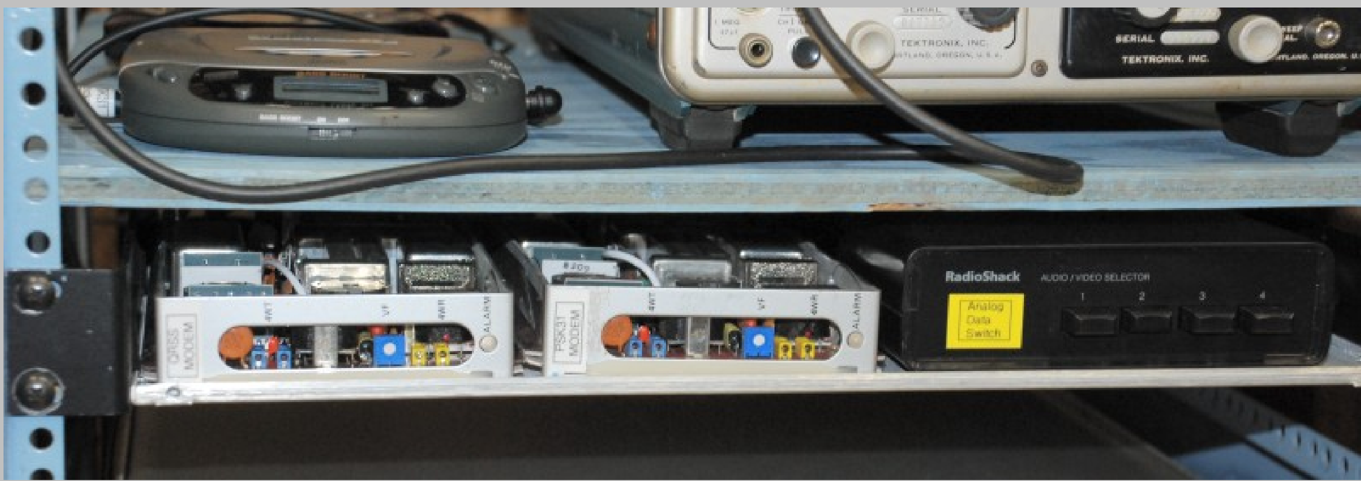
A - The E & M signal for on/off keying a relay on each modem to ring a bell or trigger some external device.

Q - Is "VF" voice frequency?

A - Yes.

Q - What do I do with "E" and "M" pins?

A - Generally, just ignore them, since they are only used for signaling between a pair of modems.



A pair of the Motorola StarPlex channel modems installed at WD2XSH/7. They are simply laid flat on a rack mounted shelf. Cardboard is used to insulate the solder side of the modems from the metal shelf. The power supply for the modems is located on the shelf, behind the push-button switchbox. The switchbox is used to select between the two modems for fast QSY between the QRSS and PSK segments of the 600 meter band. Each modem gets its audio feed from its own CD player which loops the audio times for the various modes of operation.

73, Ralph W5JGV

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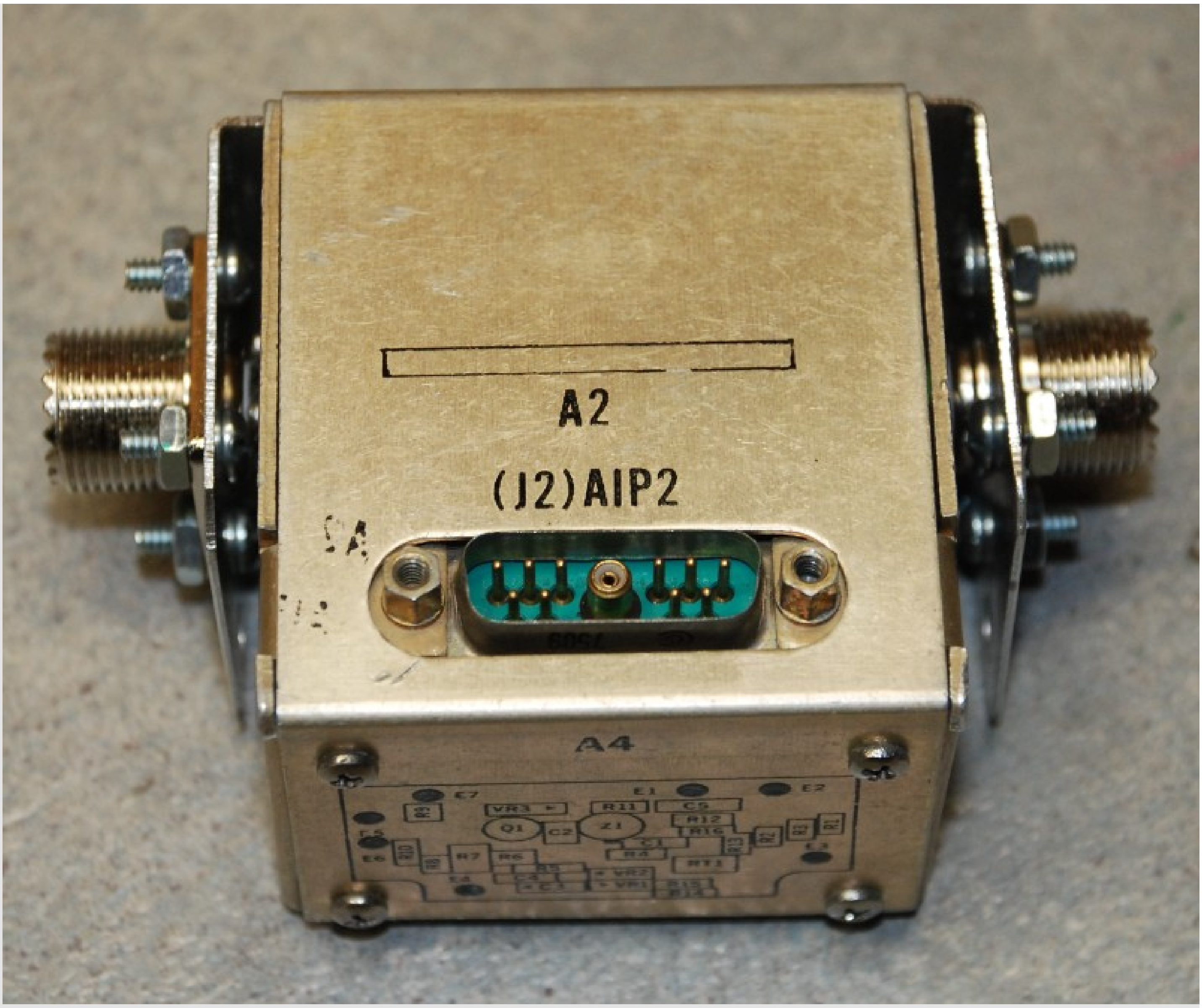
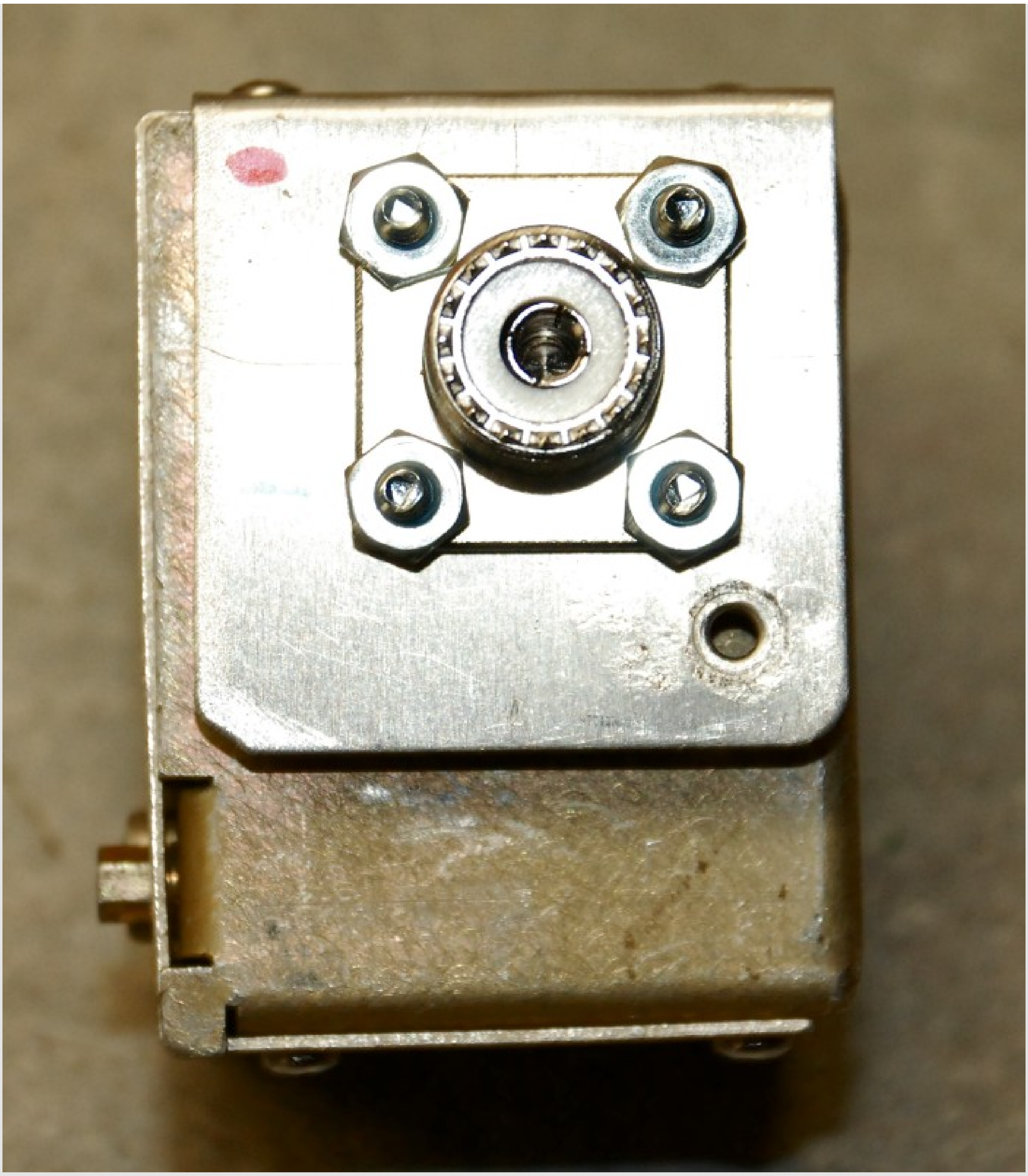
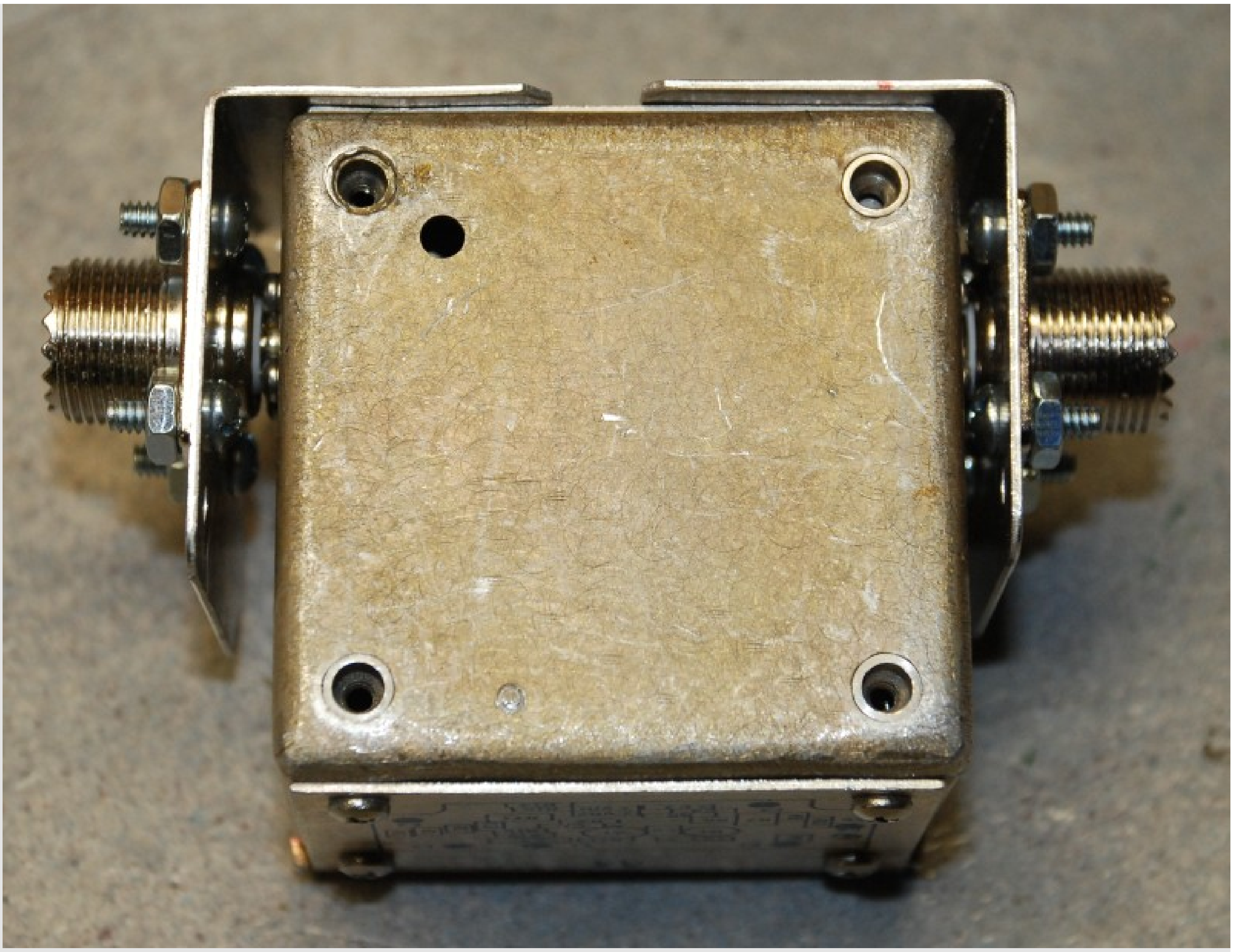


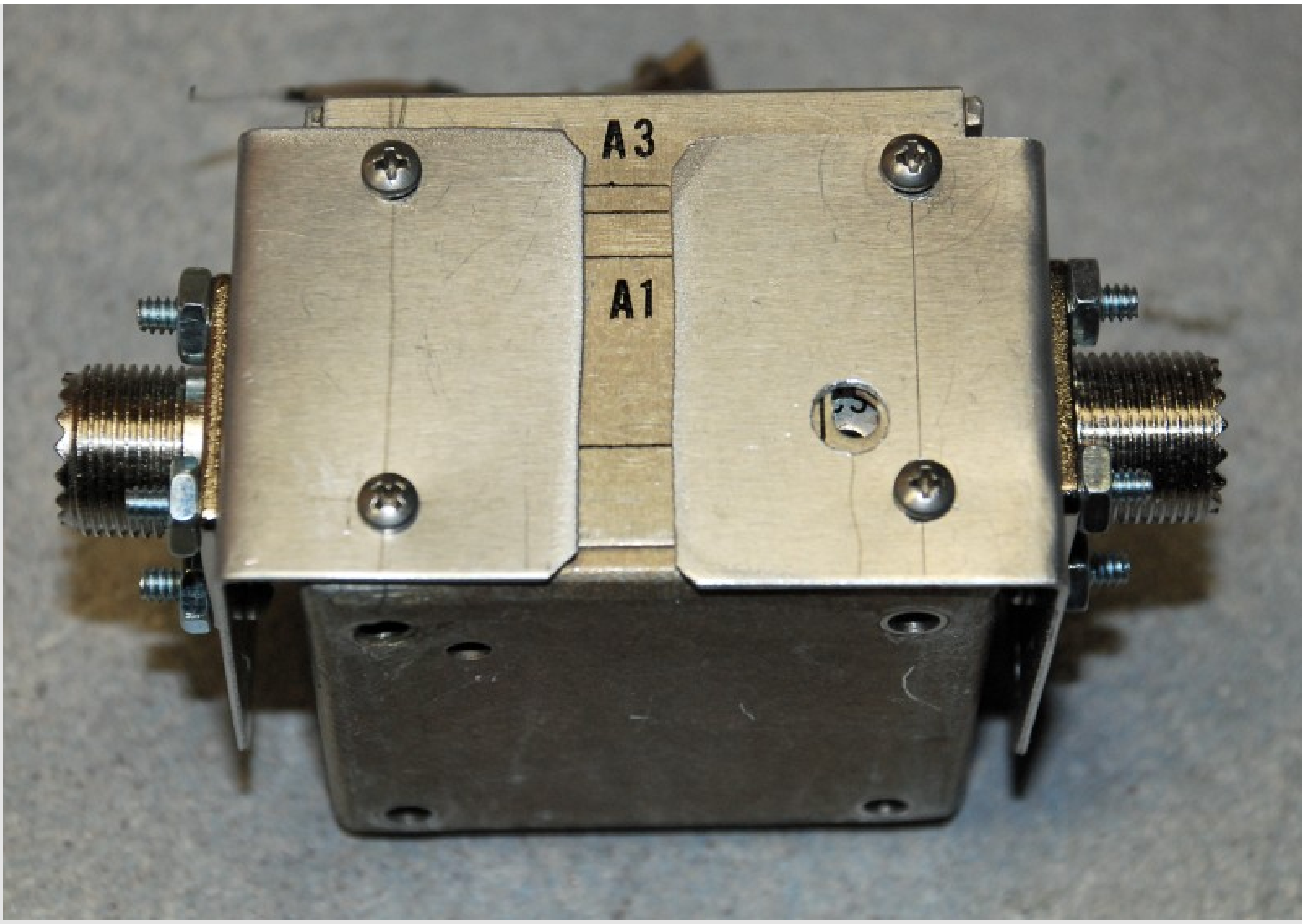
Here is the bridge as I modified it. As you can see, it is quite small.



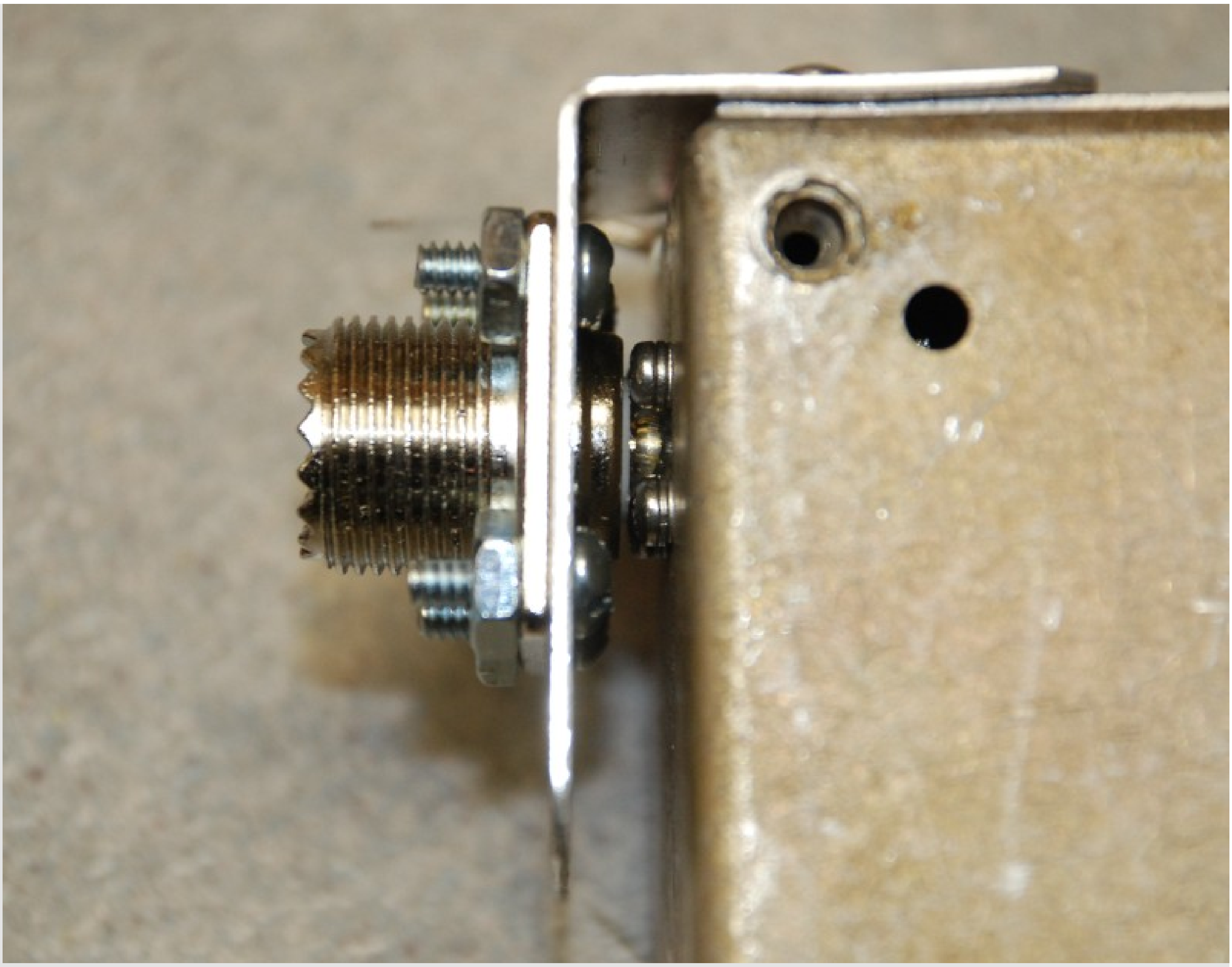
Here you can see the rough-and-ready bracket I made from scrap aluminum to hold the SO-239 connector.



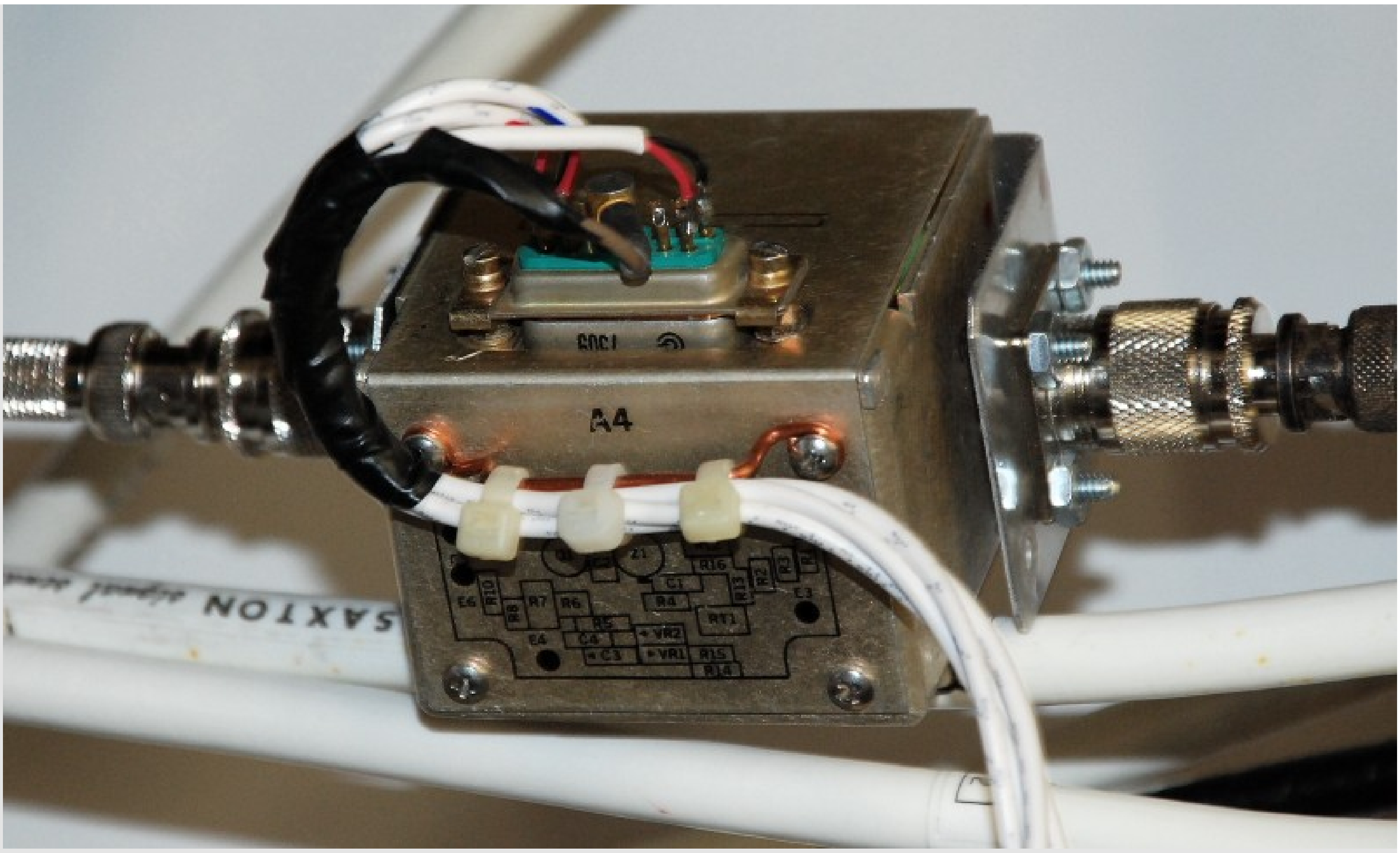
Another view of the mounting brackets.



This shows how the brackets are attached to the bridge using the existing hardware.



A close up photo showing how close the connectors are mounted to the case. The clear insulating tube can be seen over the #14 wire from the connectors center pin.



Here is the modified bridge installed in the 600 Meter transmission line. RF power enters the bridge from the left and exits the bridge to the antenna on the right. My particular bridge did not work as well if the RF connections were reversed.

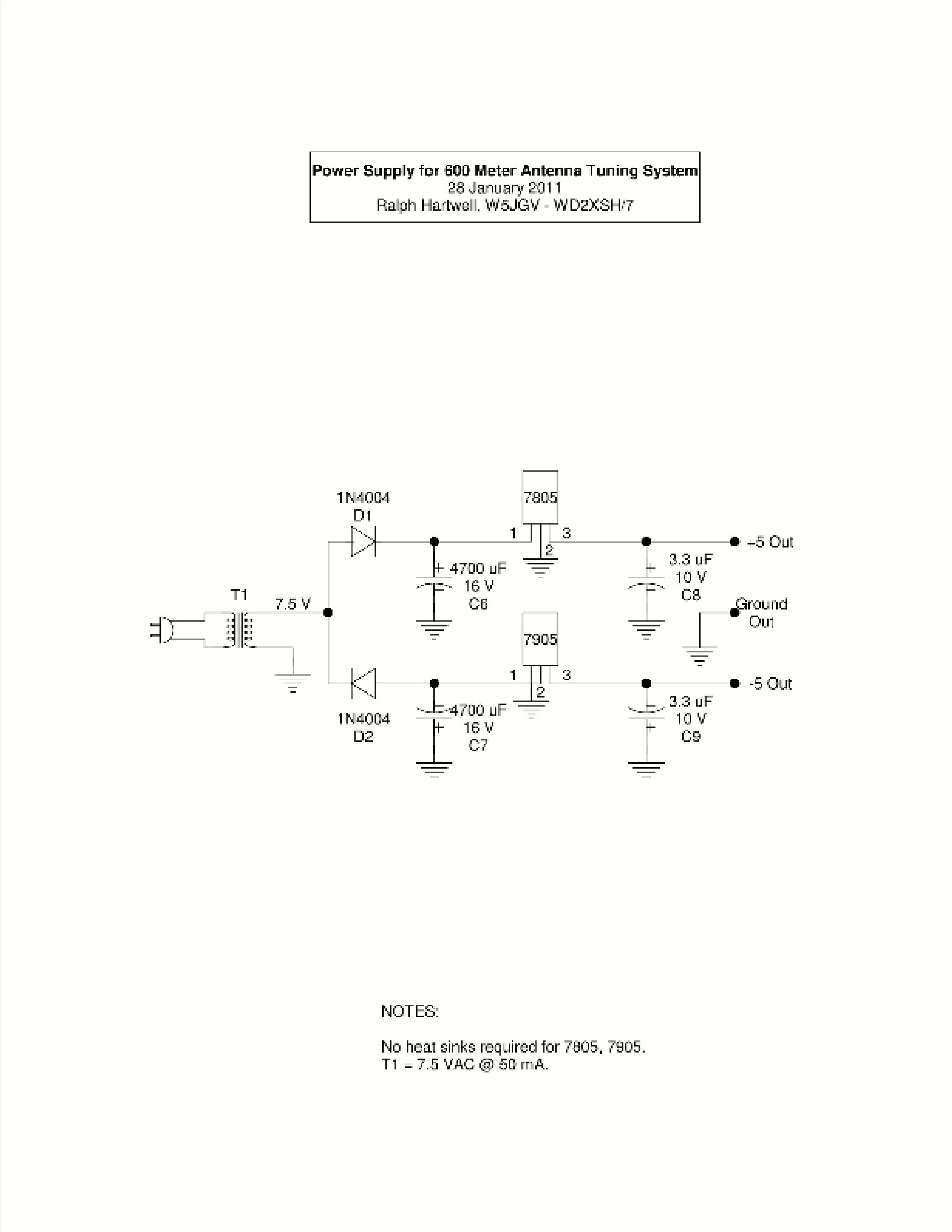
CONTROL ELECTRONICS

The control system has three parts; a Power Supply, an Op-Amp Buffer, and the Comparators.

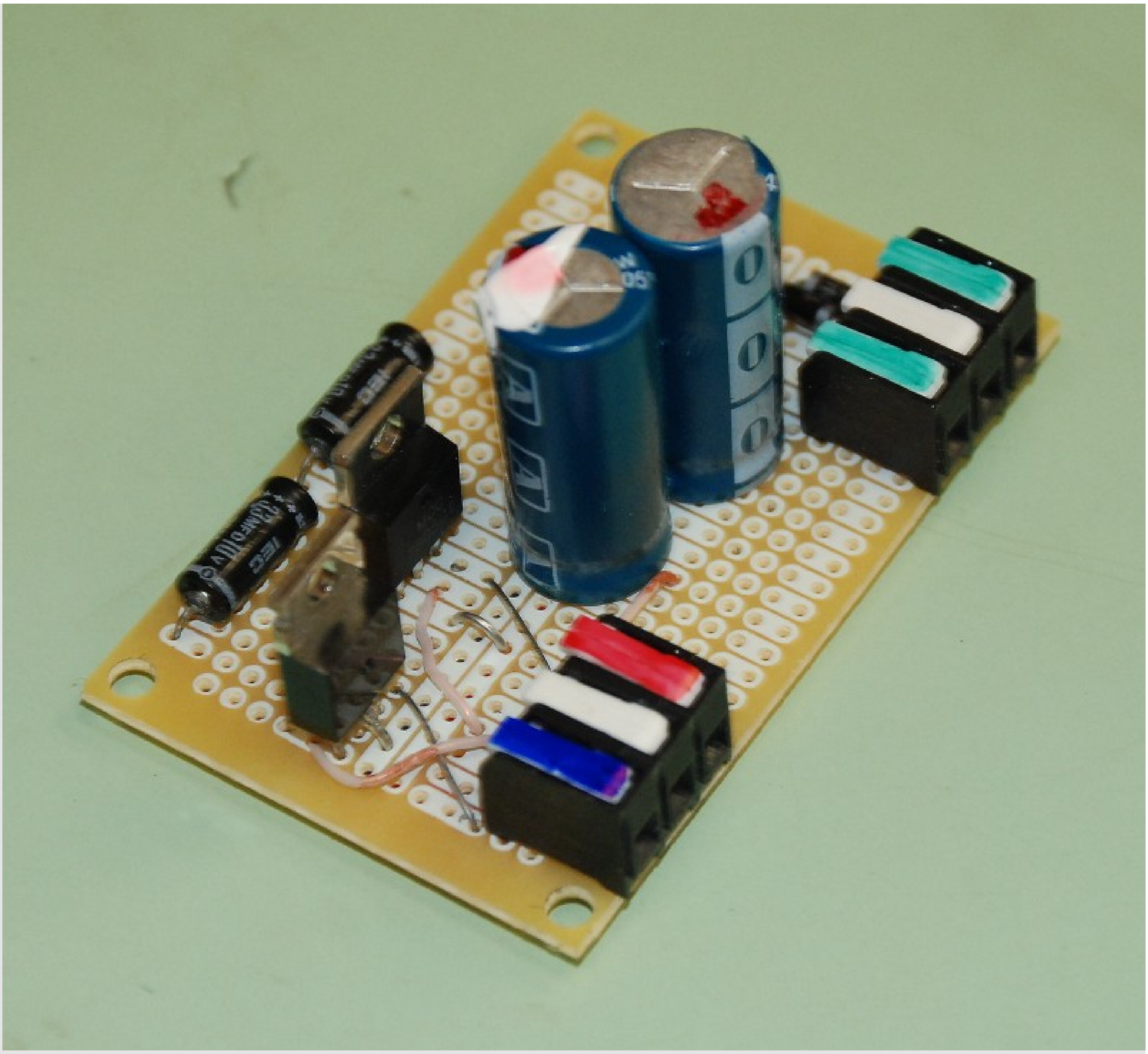
To download a print quality PDF file of the power supply, please click HERE.

To download a print quality PDF file of the Op-Amp Buffer, please click HERE.

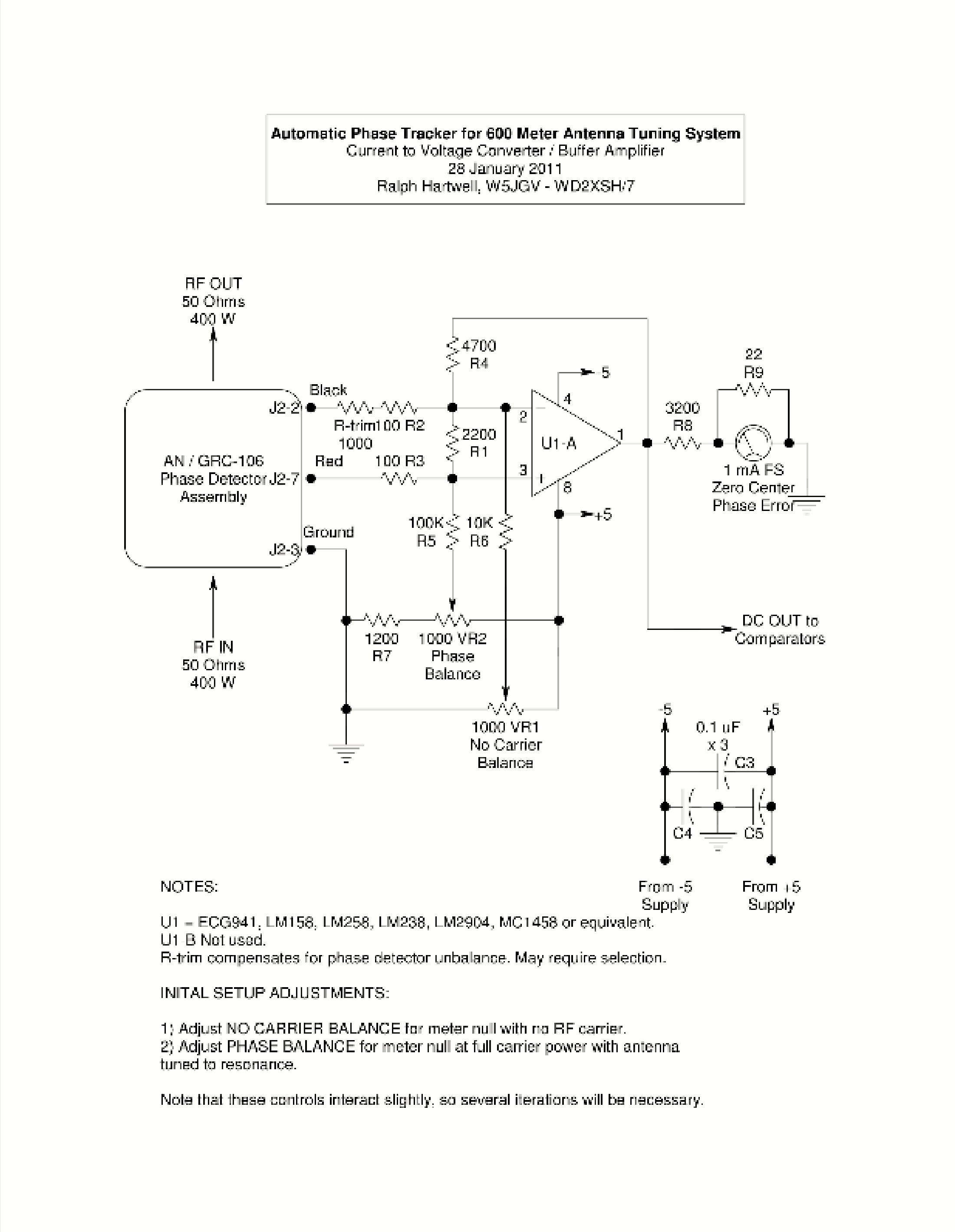
To download a print quality PDF file of the Comparators, please click HERE.



The power supply is a simple voltage regulated supply which provides plus and minus 5 volts. Since very little current is required, a simple half-wave rectification system is used for each voltage source. Because each rectifier diode draws current from the transformer during alternate half-cycles, the transformer sees a balanced load. Almost any small low voltage transformer will work. I used one which was salvaged from an old clock radio. It supplies about 7.5 volts AC. After rectification, the input filter capacitors charge up to about 10 volts, which is more than sufficient for the 7805 and 7905 regulators to function properly. Because of the low current drain from the supply, no heat sinks were required for the voltage regulators. The parts values are not particularly critical.



The completed power supply board. I used quick connect terminals to make installation easier.



The circuit of the buffer amplifier is shown here. Please note that on my particular phase detector, the pins for the output signal did not match up with the pin numbers shown on the diagram that was supplied with the unit. Your unit may or may not be different. The pins shown on the diagram, J2-2, J2-7, and J2-3 are the ones that worked for me.

BUFFER AMPLIFIER CIRCUIT DISCUSSION:

Op-Amp U1-A acts as a current-to-voltage converter with a voltage gain of about 1. The phase detector unit is rated to operate from about 20 to 400 watts. I am using mine at 200 watts. At that power level, the detector produces about 10 uA reading on a 50 uA meter for a line VSWR of 1.1:1. At a VSWR of 1.2:1, the reading increased to 20 uA, and at 1.3:1 VSWR, the reading was about 30 uA. The Op-Amp converts the 10 uA signal to about 1 volt at U1-A, pin1, the polarity of which depends on the direction of the phase error.

The current from the phase detector is converted to a voltage across resistor R1. Resistors R2 and R3 may be eliminated if desired.

Resistor R-trim is used if necessary to compensate for slight unbalance in the phase detectors internal bridge network. My unit was slightly off, and adding a 1000 Ohm resistor brought the reading back into balance.

Resistor R8 sets the full scale reading on the Phase Error meter. The meter is optional, but it is needed to calibrate the system, so I left it in the final design. R9 is used to dampen the free swinging meter needle. A 1 mA meter is shown in the diagram, but any convenient meter can be used. The meter needs to indicate full scale with about 1 volt applied to the meter. That results in roughly a half-scale reading when the VSWR error is 1:1.1.

Capacitors C3, C4, and C5 act as conventional bypass capacitors for the circuit to prevent unwanted oscillation. Due to the low gain of the circuit, no oscillations were detected even without the capacitors, but I included them just in case.

ADJUSTMENT AND CALIBRATION:

Start by making sure your antenna system is tuned to resonance. You will calibrate the phase detector to that reference point.

Insert the phase detector assembly in series with your transmission line. Be sure to insert it in the line in the correct direction.

Connect a microammeter across the bridge output connections, J2-2 to J2-7.

Apply about 200 watts to the transmission line. Make sure the antenna is still in resonance.

Note the reading on the microammeter. Ideally, it should read zero. It probably won't. Adjust the antenna tuning for a 1.1:1 VSWR reading and note the microammeter reading. Reverse the antenna tuning to the other side of resonance until you achieve a 1.1:1 VSWR. Note the microammeter reading again. This will tell you how out of balance your bridge is.

Turn off the RF power, and connect the phase detector bridge output to the inputs of your Op-Amp circuit.

Adjust the PHASE BALANCE and NO CARRIER BALANCE pots to mid range.

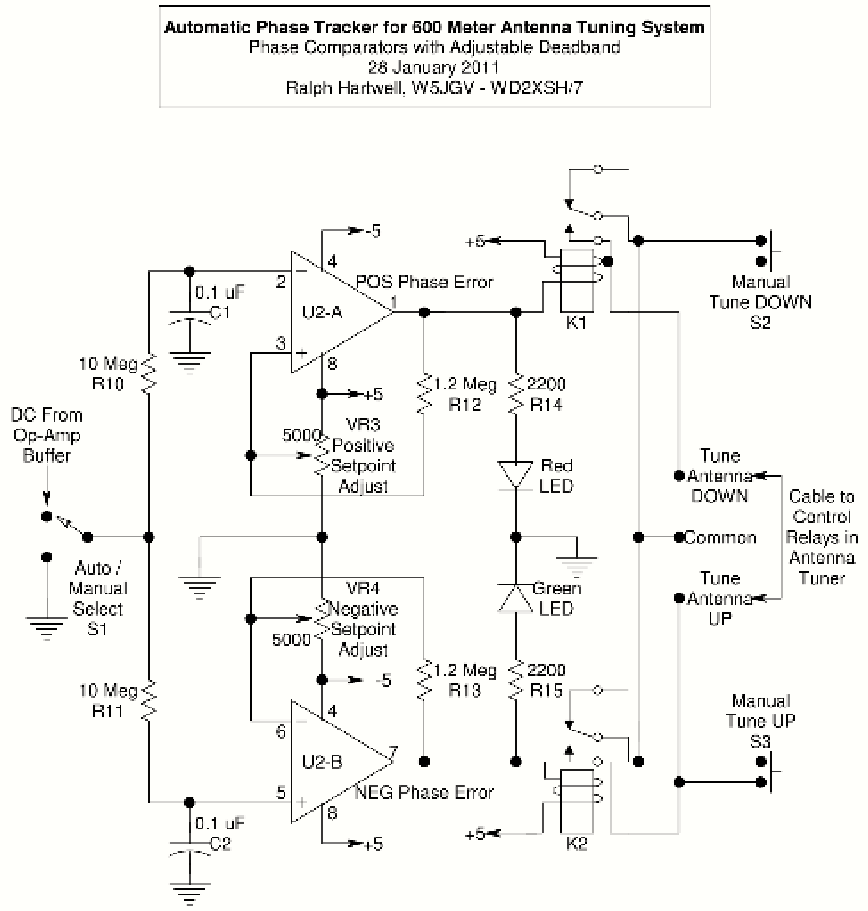
Power the amplifier up and adjust the NO CARRIER pot for a zero (center) reading on the PHASE ERROR meter.

Apply RF power to the transmission line / antenna system. Note the reading on the PHASE ERROR meter. Make sure the antenna system is still tuned to resonance and adjust the PHASE BALANCE pot for a zero (center) reading on the PHASE ERROR meter.

Shut off the RF power and readjust the NO CARRIER BALANCE for a zero (center) reading on the PHASE ERROR meter.

Note that the NO CARRIER BALANCE and the PHASE BALANCE adjustments interact somewhat, so you will have to repeat the adjustment sequence several times to get it just right. The goal of the adjustments is to achieve a zero (center) reading on the PHASE ERROR meter with no RF power, and a zero (center) reading on the PHASE ERROR meter with the RF power on and the antenna tuned to resonance.

If you cannot get things adjusted right, and you "run out of adjustment range" you may need to insert the R-trim resistor as mentioned earlier. When you finally get the adjustment right, you are done with this part of the circuit. Now it's time to go on to the Comparators.



NOTES:

U1 – LM193, LM293, LM393, LM2903 or equivalent.
K1, K2 = Potter & Brumfield T81H5D312-12, 12 VDC coil, resistance 666 Ohms.

Positive Phase = Antenna tuned too high in frequency, line reactance = -j
Negative Phase = Antenna tuned too low in frequency, line reactance = +j

Red & Green LED's are optional, but useful for setup.

COMPARATOR CIRCUIT DISCUSSION:

The function of this circuit is to detect the polarity of the error signal so as to know which way to command the servo motor to drive the antenna tuner, and the magnitude of the error signal to know when to tell the servo system to run.

The DC error signal from the output of the buffer amplifier U1-A, Pin 1, goes through a switch, S1, which allows the operator to turn the auto tune function on or off.

The varying error signal goes through resistors R10 and R11, and is integrated by capacitors C1 and C2. When the polarity of the error signal is positive, comparator U2-A will be activated. Conversely, when the polarity is negative, comparator U2-B will be activated. The larger value capacitors C1 and C2 are, the slower will be the reaction time of the comparators. That is, they will ignore rapid changes in the error signal, but conversely, the

comparator will stay triggered for a longer interval when it does trigger. To small a value can cause the comparator to oscillate back and forth about the setpoint value if the setpoints are adjusted "tight".

When the magnitude of the error voltage becomes greater than the setpoint comparison voltage provided by VR3 (positive error) and VR4 (negative error), the appropriate comparator's output pin will be pulled low, thus operating relay K1 for a positive error, or relay K2 for a negative error. Resistors R12 and R13 provide a small amount of hysteresis for the comparator action to prevent "hunting" and oscillation as the error voltage approaches the setpoint voltage.

A note here about the relays. Normally, this comparator IC cannot sink enough current to operate a relay directly because it is limited in the amount of current it can handle safely. In this case, the relay has a high coil resistance, about 600 Ohms. The relay is designed for 12 volts to be applied to the coil, but it operates quite well on 9 volts. In this circuit, +5 volts is always connected tom one end of the relay coil. The other end of the relay coil is connected to the output pin of the comparator. The output stage of the comparator is an open collector design, so it cannot source any positive voltage, it can only sink current. In this case, the emitter of the output transistor is connected to the -5 volt supply line, so when the transistor turns on, the transistor applies -5 volts to one end of the relay coil. That gives a total of 10 volts applied across the relay coil, which activates the relay properly. 10 volts across the 600 Ohm coil resistance causes a current of 16 mA to flow through the relay coil and the output stage of the comparator, which is within its allowable current rating.

The two indicator LED's and their associated resistors, R14 and R15 serve a dual purpose. They indicate that the comparator has closed it's relay, and they act as spike voltage suppressors across the relay coil.

ADJUSTMENT AND CALIBRATION:

Tune the antenna system to resonance, and be sure the error meter is reading zero, or center scale.

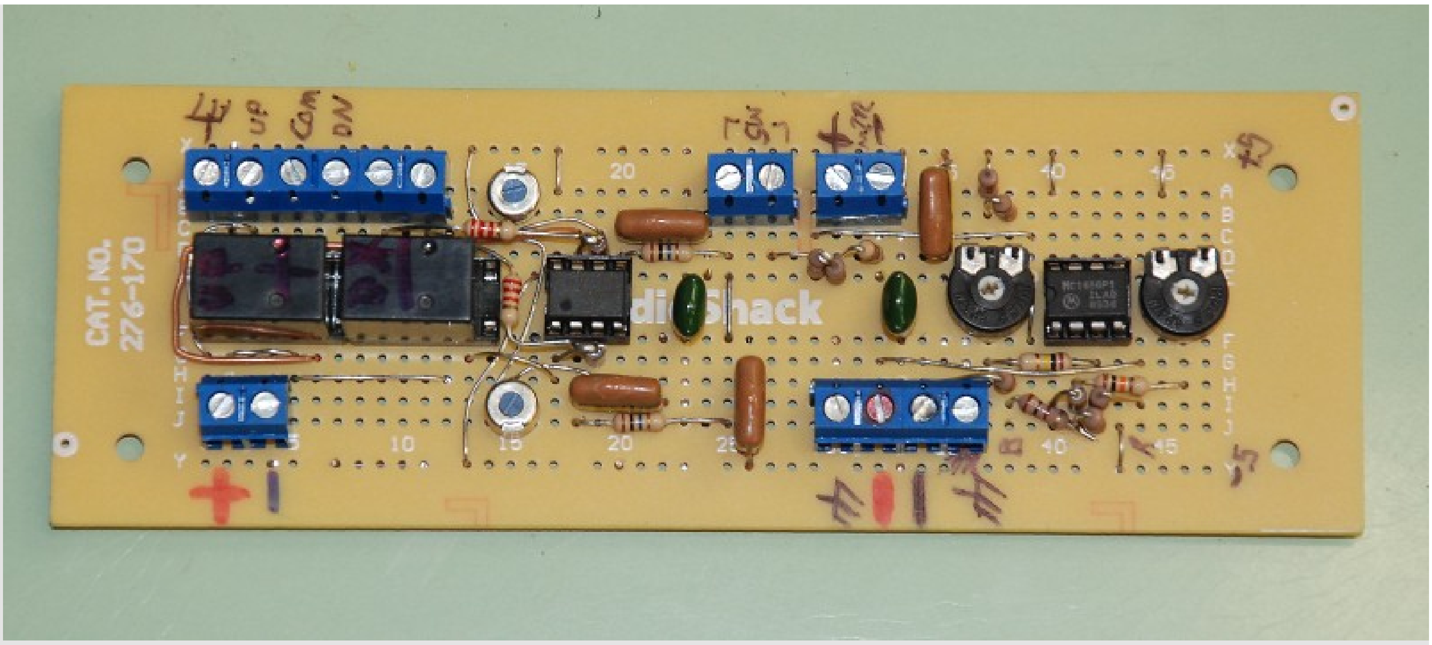
Set both Setpoint voltage potentiometers in the center of their range. If either LED is lit, rotate the appropriate Setpoint potentiometer until the LED just goes out, then turn it a bit more in the same direction.

Detune the antenna system slightly (about 1/4 scale deflection on the error meter) by pressing one of the Manual Tune buttons.

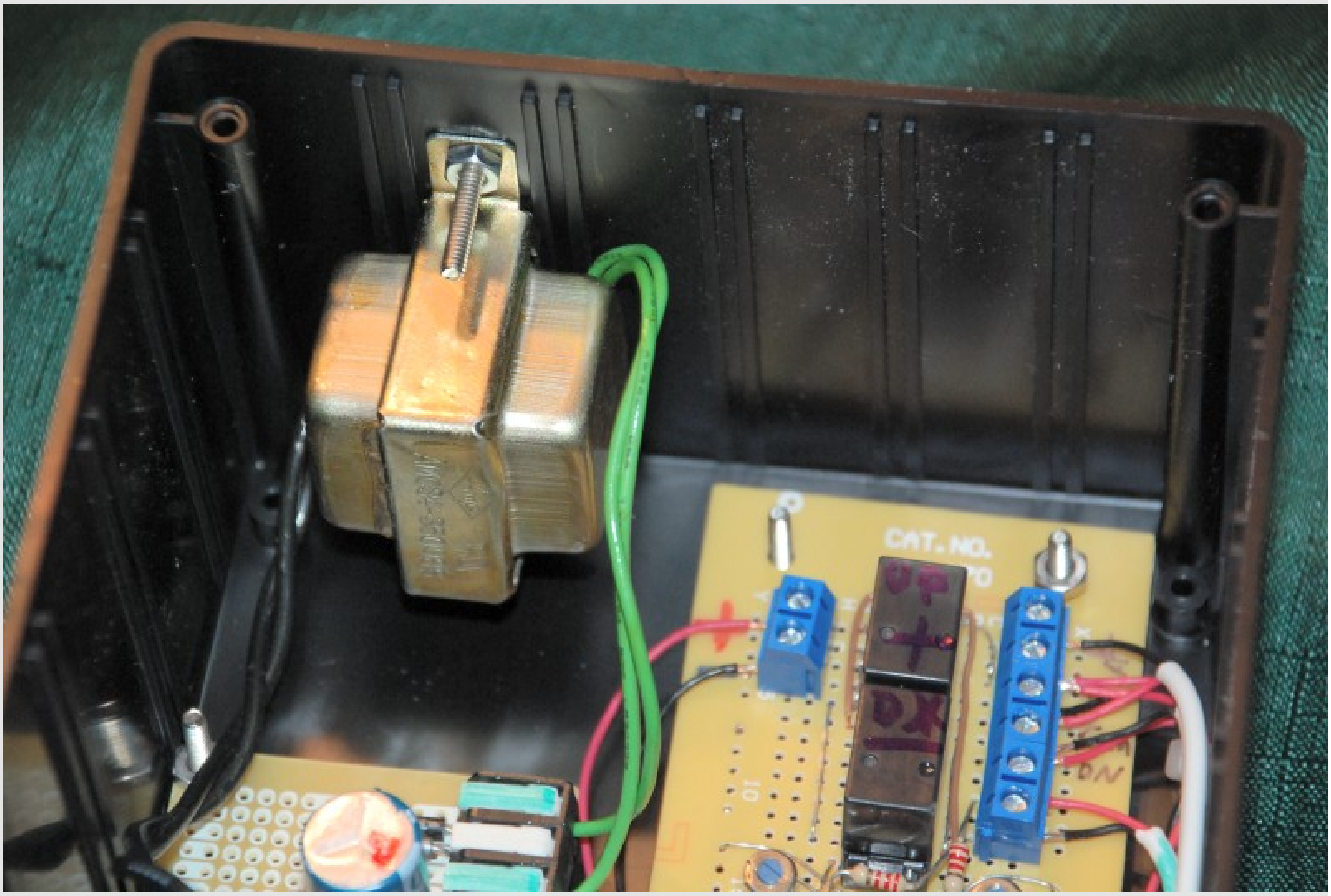
Adjust the appropriate Setpoint potentiometer so that the comparator triggers and the tuner returns the antenna system to resonance. Note that depending on the speed and sensitivity of your servo system, the tuner may overshoot the mark badly. In that case, you need to either modify the servo system so the tuner operates slower, or adjust the setpoint potentiometers to allow the system to get further off resonance before the comparator triggers. Reducing the values of C1 and C2 will reduce the lag, but may cause servo oscillations. Some "playing around" will likely be necessary here.

Repeat the adjustment for an error in the opposite direction using the other setpoint potentiometer.

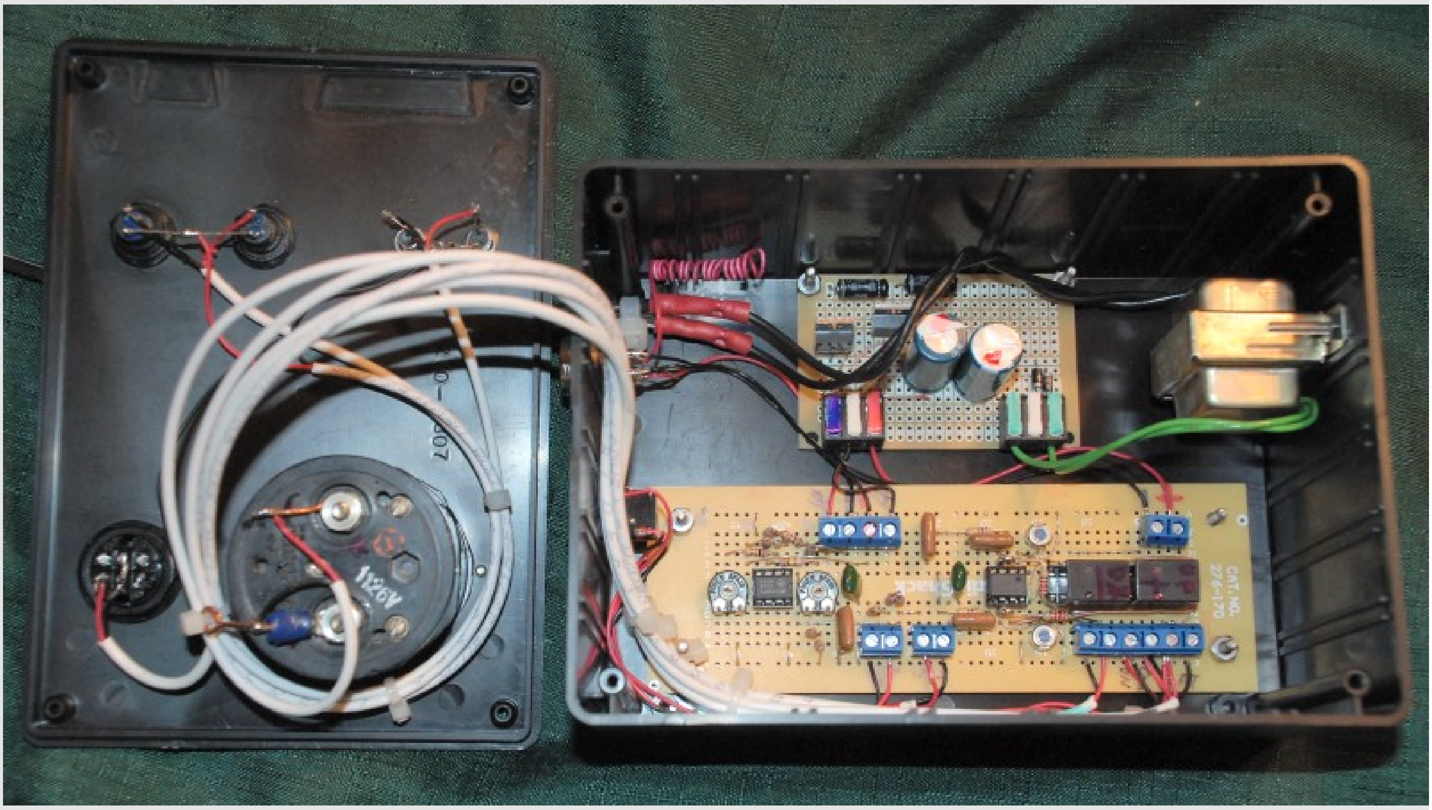
CONSTRUCTION:



The Op-amp buffer, comparator stages and relays are all assembled on a single section of pre-punched circuit board. Point to point wiring is used. No special construction techniques were used. Screw terminals were used to make final assembly easier, although they are not necessary. Note that the power supply is on a separate circuit board.

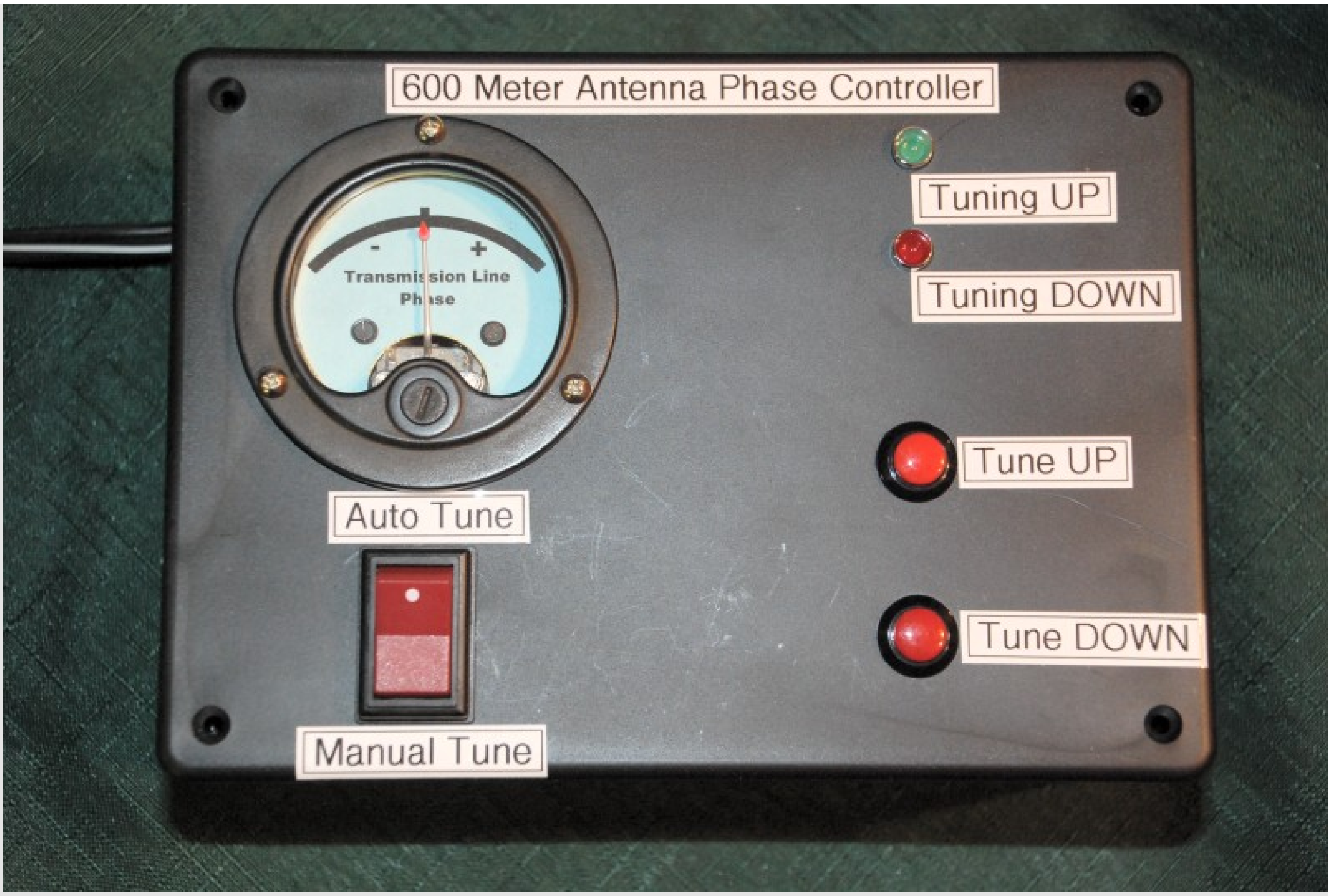


The power supply transformer is mounted in one corner of the plastic enclosure that houses the completed unit. Note that there is no center tap required on the transformer secondary. The control relays may be seen at the top end of the circuit board.



The circuit boards and power transformer are shown here in the finished unit. The phase error meter, manual up/down switches, LED's and the auto/manual switch are all mounted on the front cover of the enclosure.

The mains power cord exits from the side of the enclosure. Also installed on the same side of the enclosure are the connectors for accepting the phase error signal from the phase error detector, and a 3.5 mm 3-conductor stereo jack for a standard stereo cable. This jack is used to send the relay contact closures to the servo system to operate the tuning drive motor.

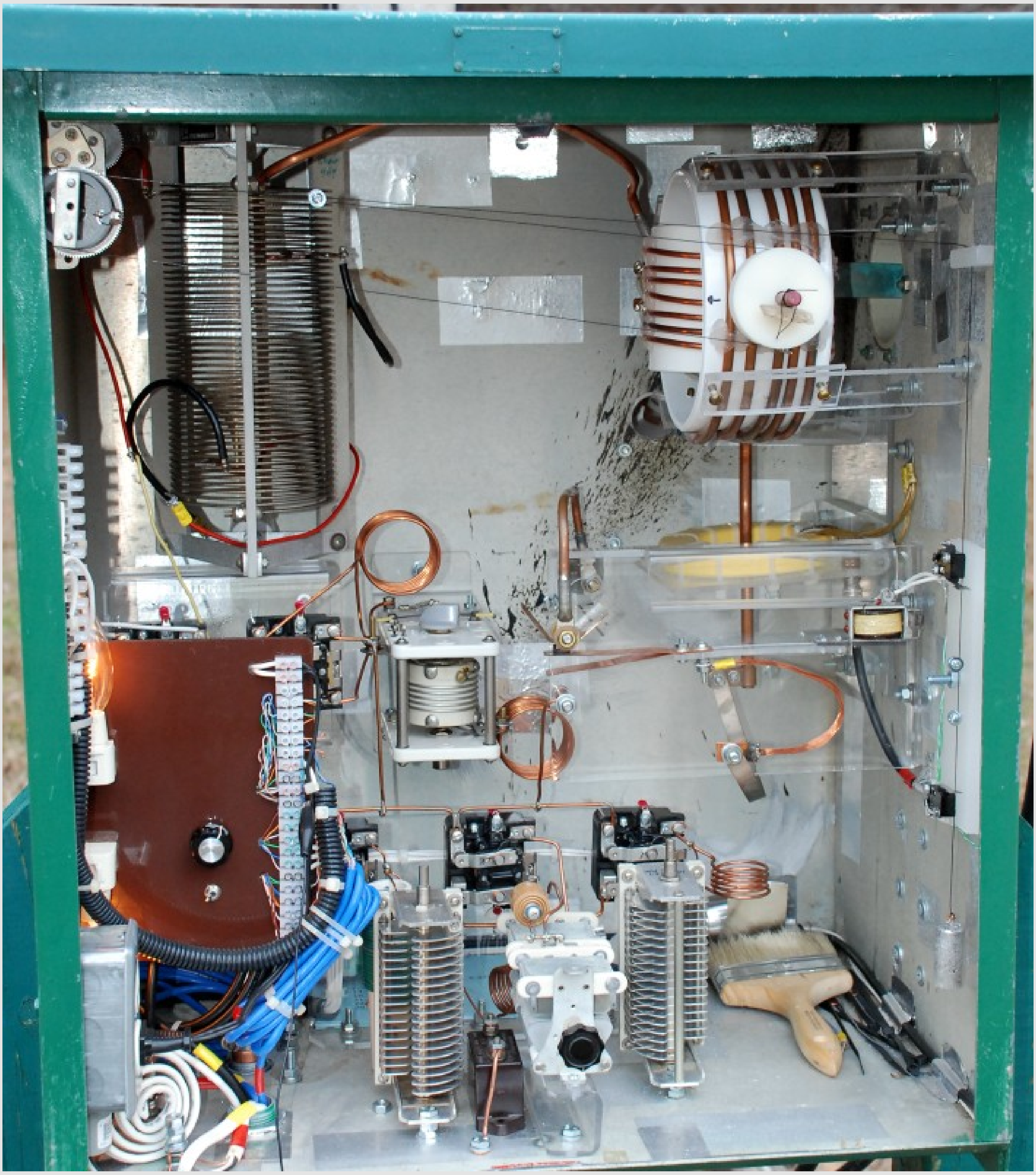


The finished control system enclosure.

Here is the controller in service showing the cables connected to the unit. Note the phase error meter is indicating that the antenna is tuned just slightly low in frequency, and is indicating a +j error. The comparators

will not switch to retune the antenna system until the phase error meter indicates an error about half way between the center scale zero phase error marker and either the (+) or (-) signs on the meter scale. In my tuner, the trigger error voltage equals a VSWR error of about 1.05:1. This is what I consider "tight" tuning.

SERVO SYSTEM, LIMIT SWITCHES AND VARIOMETER



This is the matching system for the 72 foot vertical antenna at W5JGV / WD2XSH/7.

The 600 meter components are the top 10 turns on the edge wound vertical coil at the upper left of the picture. This coil is connected to the white variometer seen in the upper right of the picture. The output of the variometer passes through the rear of the cabinet, and then on to the main loading coil. Then the RF comes back into the

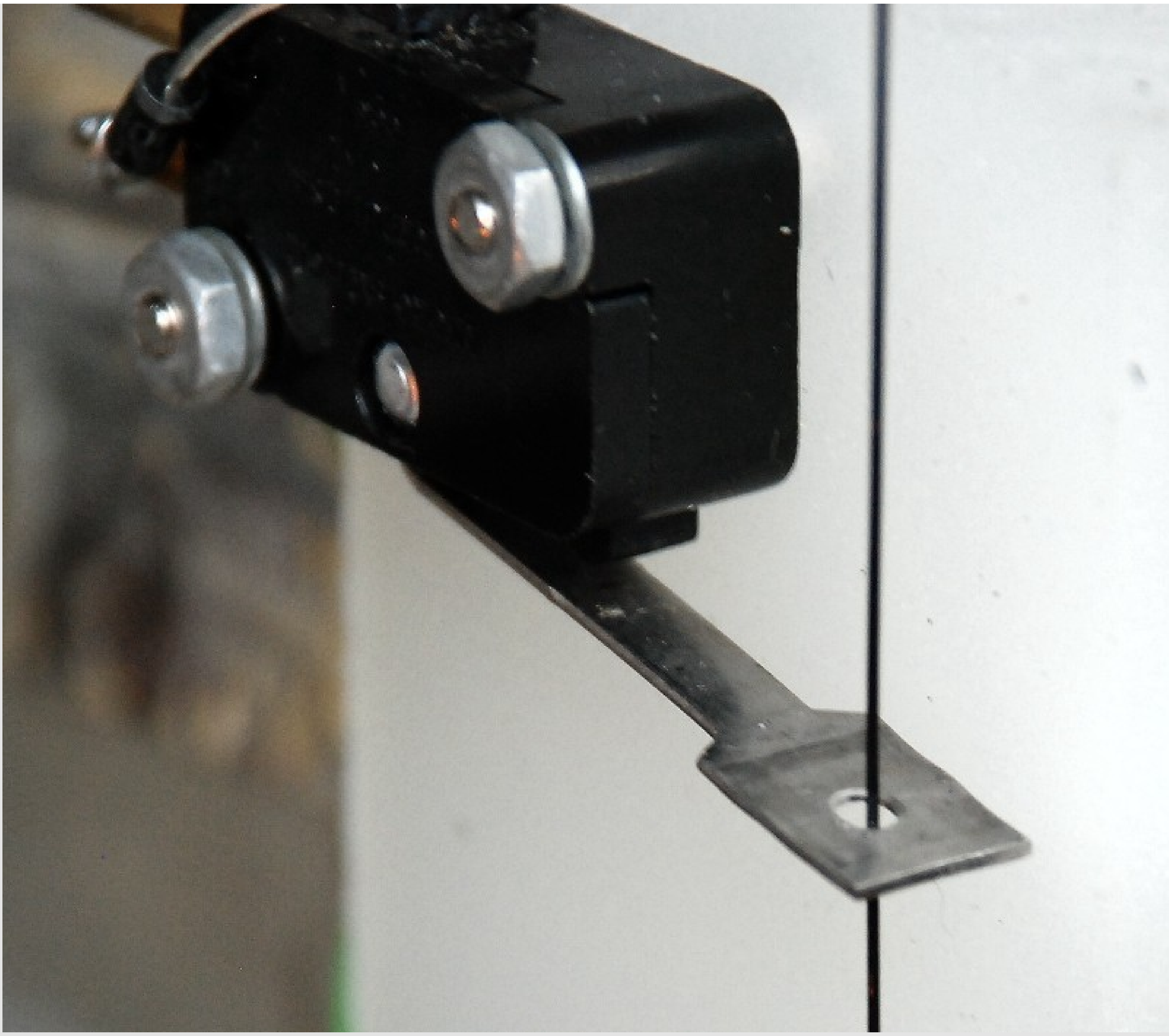
cabinet and passes through the large yellow powered iron core which is a current transformer for my remote RF ammeter to read the antenna current.

The variometer is operated by the small servomotor system which is seen in the extreme upper left of the cabinet, in front of, and to the left of, the edge wound coil. If you look closely, you can see the thin black fishing line that runs between the white pulley on the variometer and the gray drum on the servo system.

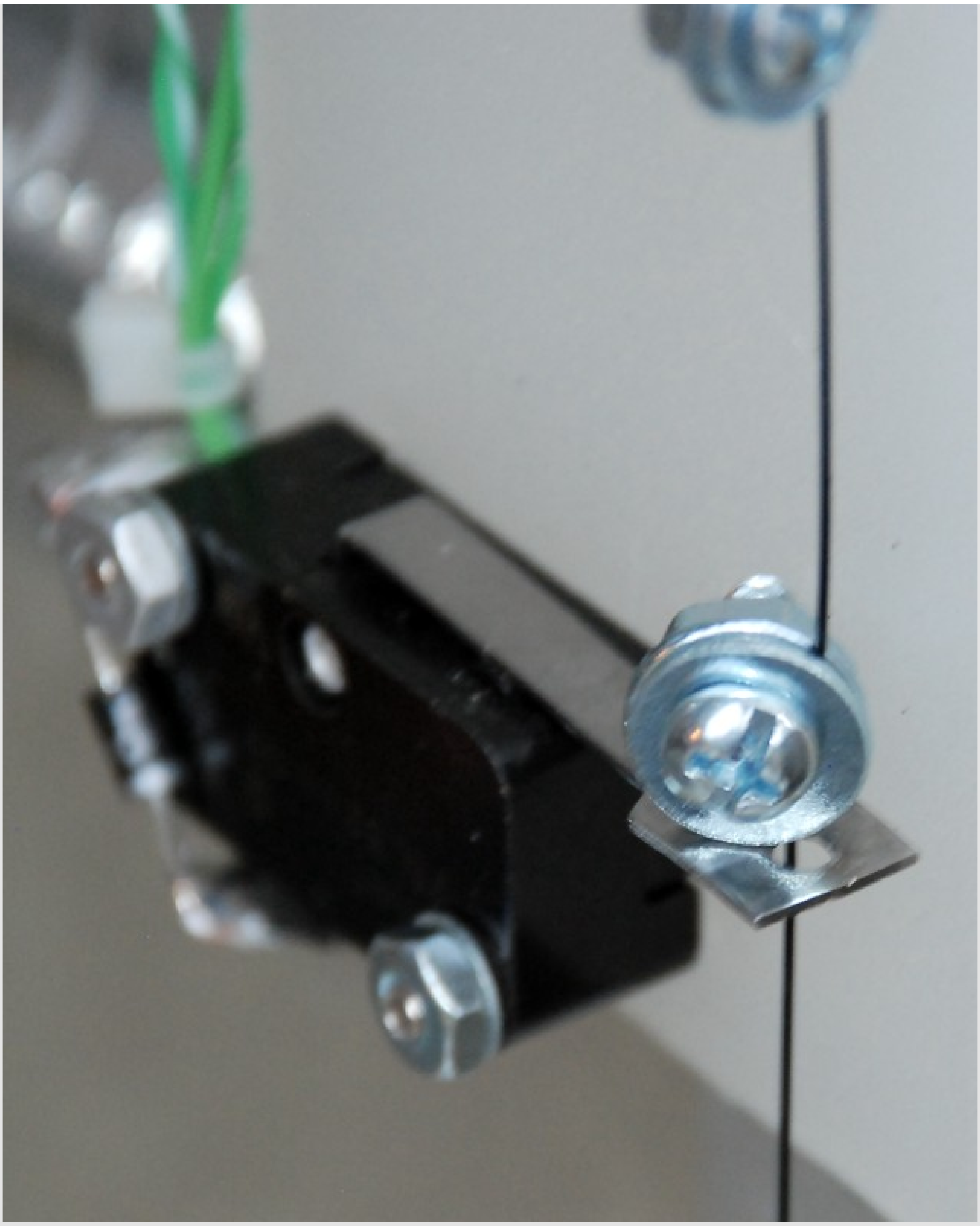
Also, note the additional length of fishing line which is attached with a silver clamp assembly to the top of the variometer drive wire. (The clamp is seen in front of the right hand support bar of the vertical edge wound coil.) This extra line goes to the right wall of the tuning cabinet and passes through a plastic block, then through the actuating levers of two snap action switches which act to limit the rotation of the variometer.

After passing through the switch levers, the fishing line connects to a small cast lead weight. The weight keeps the line taut, and provides enough weight to trip the lower switch when the line is paid out by the servomotor drum.

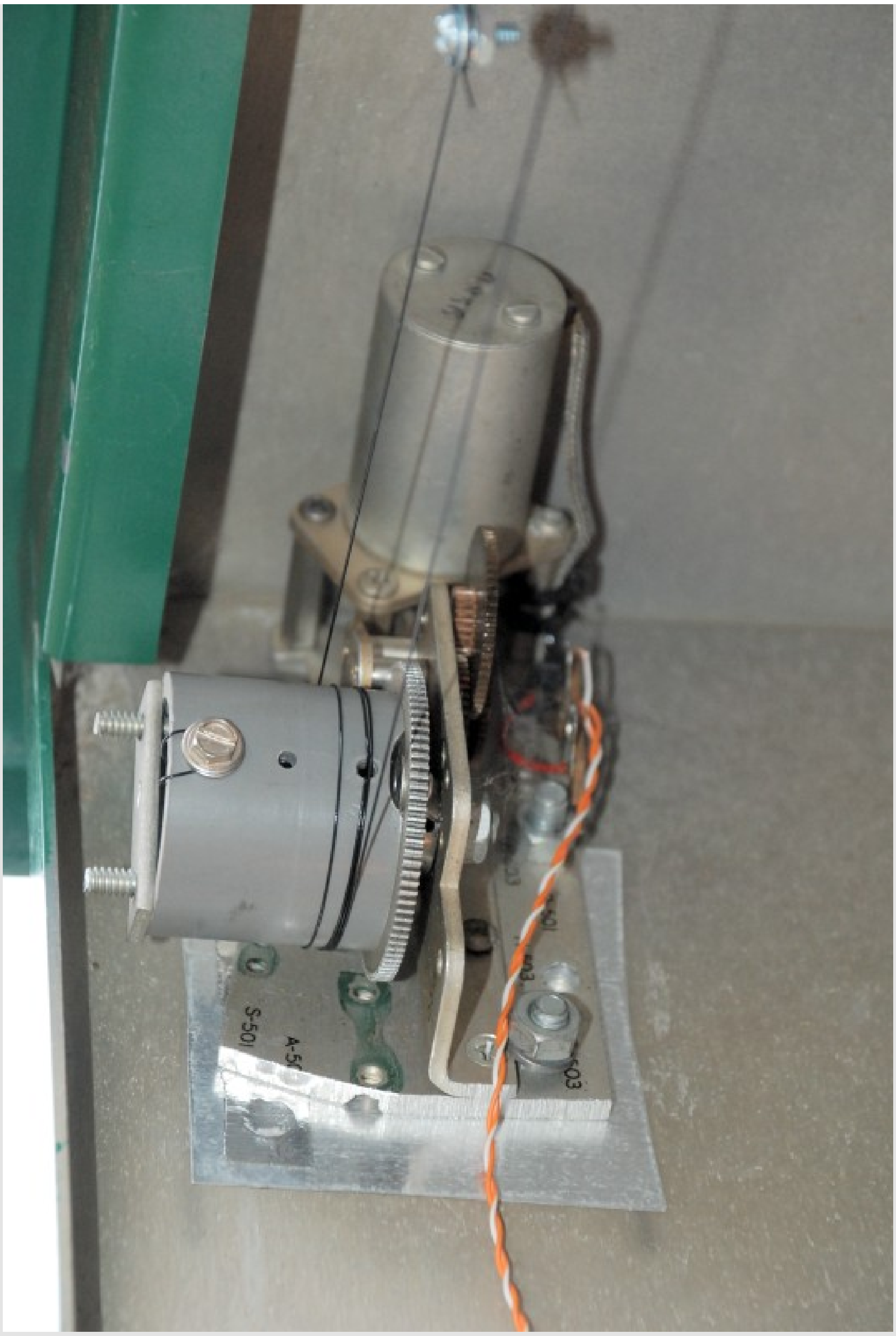
The limit switches are mounted on a section of HDPE plastic cut from a kitchen cutting board. The plastic mount is bolted to the tuner cabinet wall. The plastic block that acts as a 90 degree bearing point for the fishing line may be seen at the top of the photo to the right of the variometer, which is seen in the center of its tuning range. A pulley would have been more mechanically appropriate, but in this case, the movement of the fishing line is very slow, and the friction is low enough so that a simple rounded surface for the line to slide over was adequate. The two limit switch trippers may be seen on the fishing line between the two switches. The switches were salvaged from a discarded microwave oven.



The lever on the switch was flattened and then a small clearance hole was drilled through it to allow the fishing line to pass through it. Both sides of the drilled hole were chamfered to prevent abrading the line during operation.



The switches are tripped by a simple arrangement consisting of two flat washers which are clamped against the fishing line by using a machine screw and a nut. This allows for easy adjustment of the switch trip points should it be necessary to change the setting.



This is the little servomotor system that I use to drive the variometer. It was salvaged from a defunct vacuum variable capacitor assembly. I attached a length of PVC pipe to the large gear. The drum takes about 30 seconds to revolve through the one turn necessary to operate the variometer through the half-turn it requires to go from minimum to maximum inductance.

73, Ralph W5JGV

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Advertising Info

KG7GTE 2 Meter Slim Jim Antenna Project from Arizona

Arizona's most famous nickname is "The Grand Canyon State".
It also has another nickname,
The "Copper State" (The state of copper Antennas!)

KG7GTE Shares A First Time Experience Building the Slim Jim Antenna for 2 Meters

Parts, and cost:

10	1/2" copper pipe	foot	$1.03	$10.25
2	1/2" copper end caps	each	$0.74	$1.48
4	1/2" copper 90 elbow	each	$0.74	$2.96
			sub total	$14.69
			sales tax	$1.51
	Safford, AZ Home Depot		total	$16.20 (2013 prices)

Slim Jim Metric Formulas used in the construction of the Slim Jim:
(For results in meters)
(For results in Centimeters, multiply results by 100)

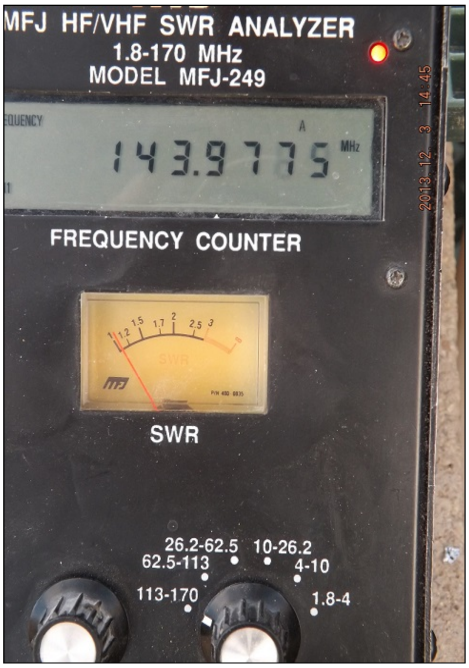
213.74 / fmhz = 3/4 wave overall length
142.496 / fmhz = 1/2 wave length
71.248 / fmhz = 1/4 wave length
Feed point = About 10 to 20% of 1/4 wavelength (+ - tuning)
75 / fmhz = 1/4 wave "freespace" in Meters
Note: These formulas are believed to be accurate. Some trimming or tweaking of lengths may be needed with YOUR construction!
[See the "Slim Jim Antenna Project" on Hamunivere.com here!]

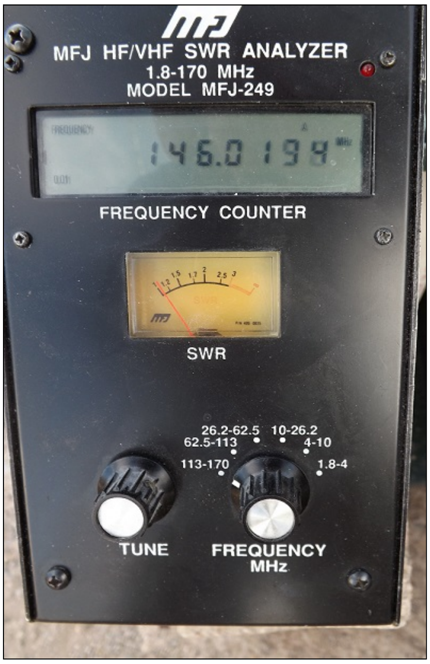
I put the formulas above into excel, and cut the individual pieces as close as I could get with the exception of the 1/4 wave section which I cut 1" short.

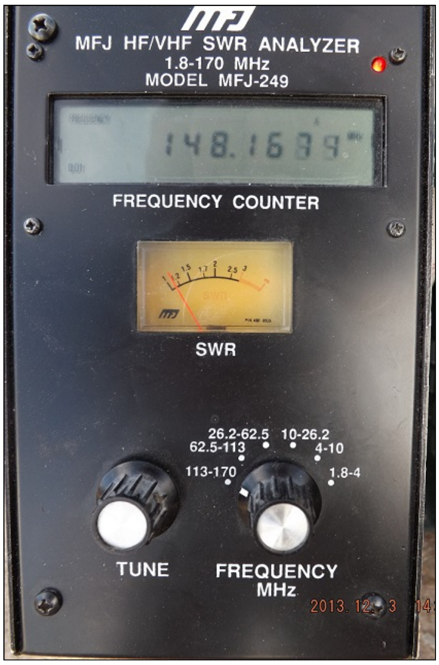
Construction was straight forward, and very easy, however I did learn that you do not want to use a welding torch for soldering.. WAY TO MUCH HEAT as is evidenced by the photographs. The center feed is a piece of #10 electrical wire cut to length, and soldered to the center of the SO239, and again I learned that you DO NOT want to do this with the antenna in a vertical position ,see the evidence in the pictures. I put a small bend in the wire, lined up the torch where I wanted it, grabbed the feed with a pair of pliers in one hand and the solder in the other.. it worked, but holding that sucker in place while waiting for the solder to set was a pain. Then I soldered the SO239 to the other side.

For testing, and pictures, the bottom edge of the antenna is located 525mm (23 inches) above ground level.

I used an old MFJ-249 Antenna Analyzer and connected it to the feed point with a 1' section of LMR400,
VERY HAPPY CAMPER HERE. The swr is nearly flat across the entire 2meter band. As evidenced by the accompanying photographs. See photos below for swr readings across the 2 meter band.







The SWR readings above were taken using an MFJ-249 Antenna Analyzer and the antenna was fastened to a piece of 1 1/4" Schedule 40 PVC with the bottom of the antenna about 20" off the ground. The coax is a 1' section of LMR400 with a PL259 on each end. See photos below for testing setup, air gap and SO239 connection.

Test setup

Covered Air Gap on left------Feed point connection on right

The antenna is 1500mm (59.1 inches) overall {SEE IMPORTANT NOTE BELOW}, and center to center of the vertical elements is 50.8mm (2 inches). The air gap is 36mm (1.4 inches) and the feed point is 252mm (9.9 inches) above the bottom edge of the antenna.
I used a few pieces of old 1 inch board cut to fit between the verticals, which are held in place by black zip-ties. To cover the air gap I used a piece of old 3/4" heater hose.

The major connection points were sealed with an aerosol spray to protect it from weather especially at the SO-239/PL-259 feedpoint.
Important note....don't forget that the 90 degree elbows are included in the overall length of the vertical section lengths so you should use 58.1 inches total length from top to bottom instead of 59.1 inches like I did.

Slim Jim up and mounted in left picture --- Slim Jim and "UFO Tracking antenna" in right picture!

~Additional notes about construction and results~

I had planned on making a change, by threading one of the end caps and putting an adjusting bolt so that the air gap could be modified in hopes of making it easier to fine tune the antenna, however, my taps were no longer in the shop, so I ended up with a MUCH wider air gap than was calculated. However it did not seem to hurt though it did raise the feed point drastically.

I stripped the insulation from a section of #10 Electrical wire and soldered it into the SO239 connector. What I will do next time is NOT try to solder this connecter onto the antenna with it in a vertical position. You will really laugh when you look at the pictures, I had solder dripping all over the place.

I did do one other thing, I cut a piece of 2x4 down until it just fits inside the 1 1/4" PVC in order to stiffen it.
This should prevent movement from the wind, which often reachs 50-60 miles per hour here.

Closeup of mounted antenna

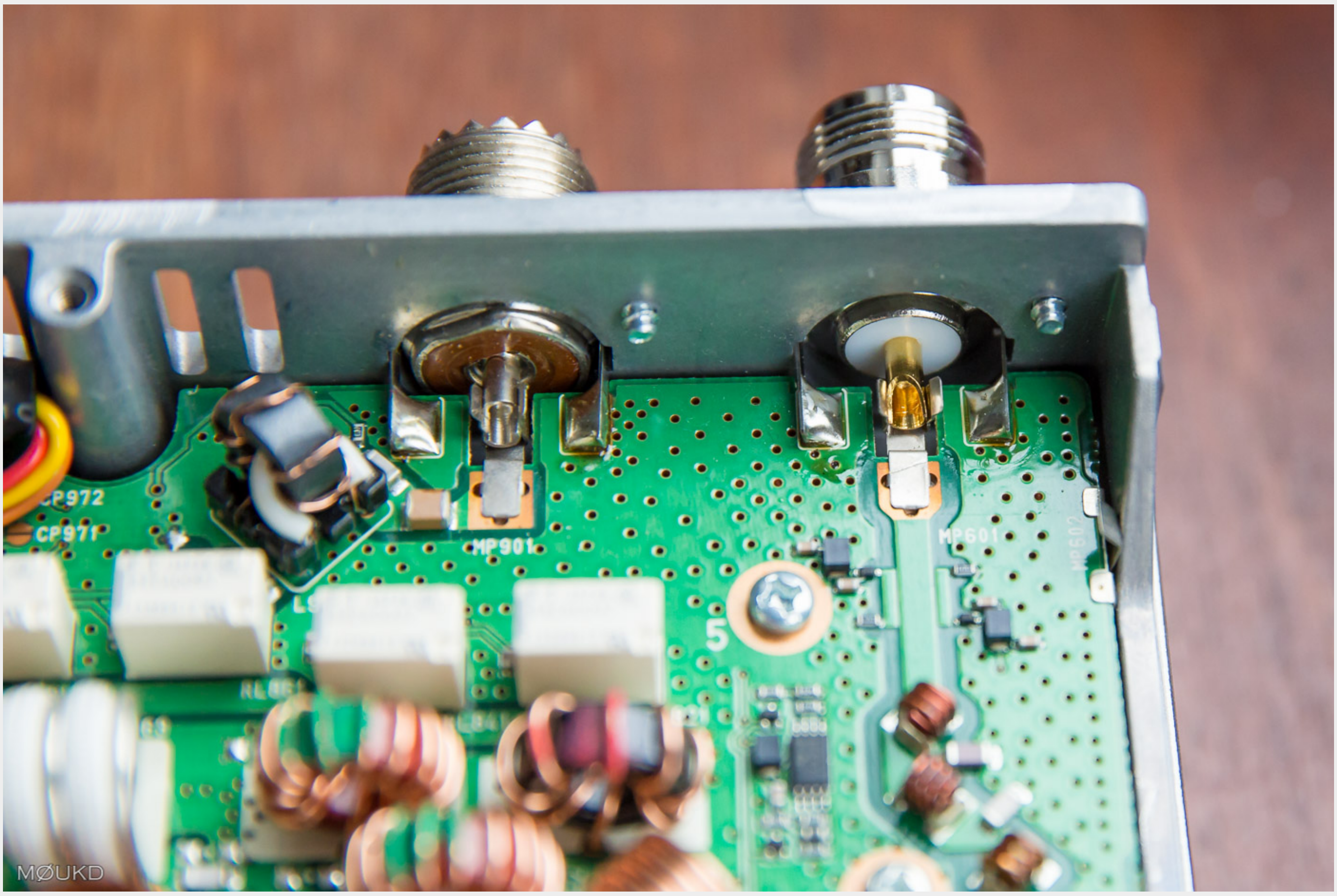
On the air testing!
I ran a check with the analyzer from inside now that the antenna is up and the swr is just below 1:1.2 at 144 and just below 1:1.5 at 148. The swr did go up some vs testing on the ground, but still within limits. I was a bit disappointed in the lower limits being at the bottom of the band, was hoping that the center would be the lowest point. Hey, for $16 I can always build another to "perfection"!!!

Got it up in the air, 5.8 meters (18.8 feet) above ground, and connected to the hand held. Had nice clear reception of a conversation I could not even see was going on using the hand held rubber duck when the scan stopped, but there was not a signal strength indication so I switched to the Slim Jim.. Signal was full bars on the hand held and everything was clear. Found an open channel and worked a party in Tucson, air miles from my QTH to the repeater is approximately 45 miles.
He reported full quieting of my signal from the repeater....good enough for me! Now more on the air fun starts!
Have fun building yours,
73 KG7GTE - James

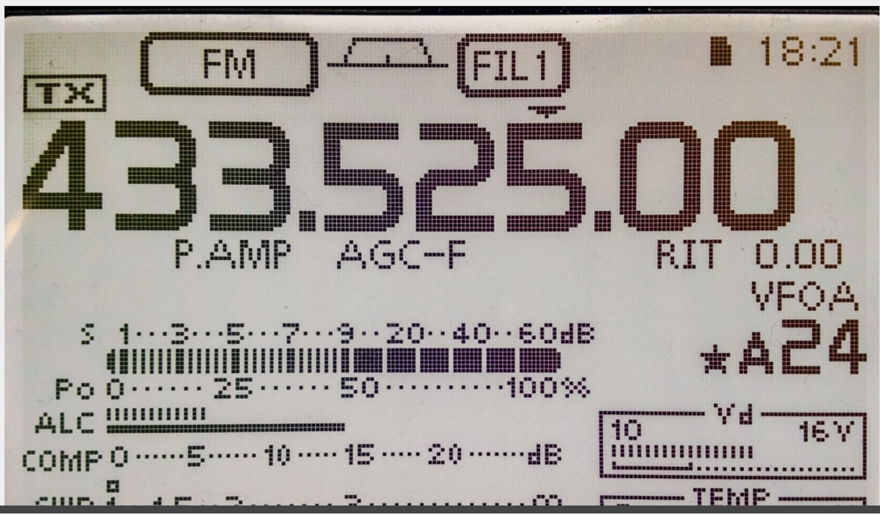
Credit for the original design goes to F.C. Judd, G2BCX.

Plans for this project taken from the original article on Hamuniverse.com [here!]

Icom IC-7200 SO-239 to N-Type Socket




MIC
SP
REMOTE
DATA2
DATA1
ACC
MØUKD


TX
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FIL1
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433.525.00
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AGC-F
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VFOA
★A24
S 1···3···5···7···9··20··40··60dB
Po 0······25······50··········100%
ALC
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Vd
10
16V
TEMP

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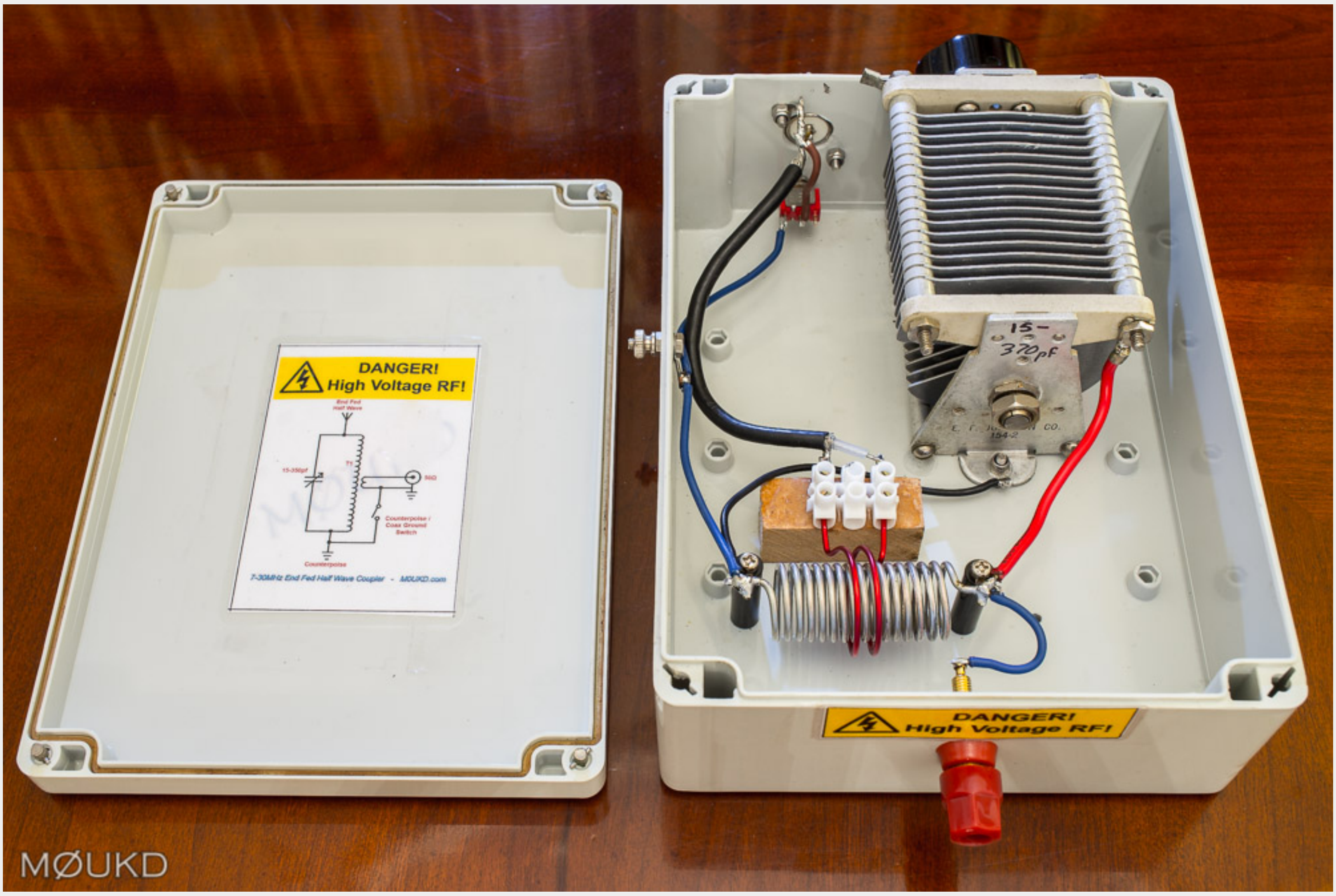
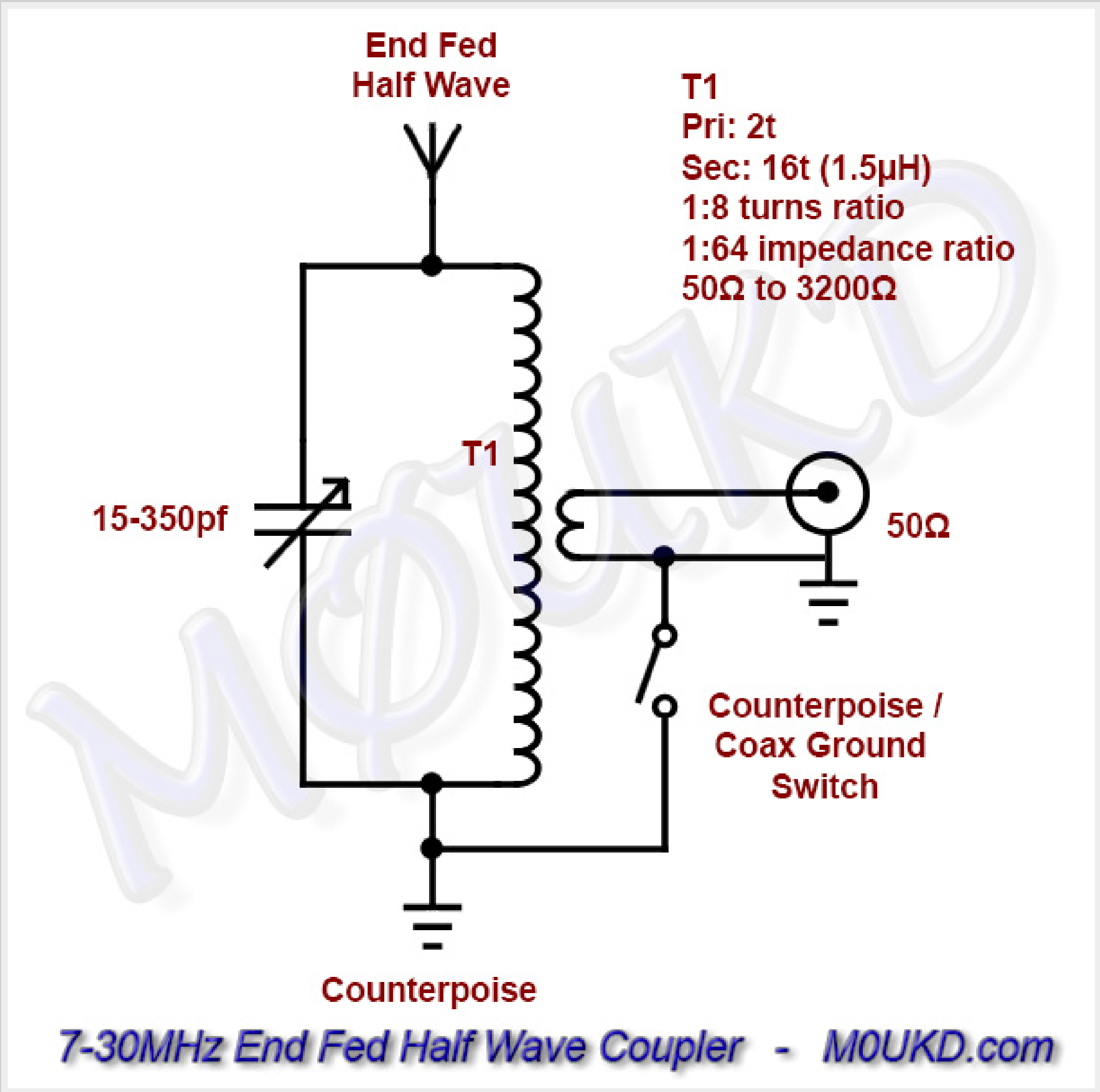
Accept

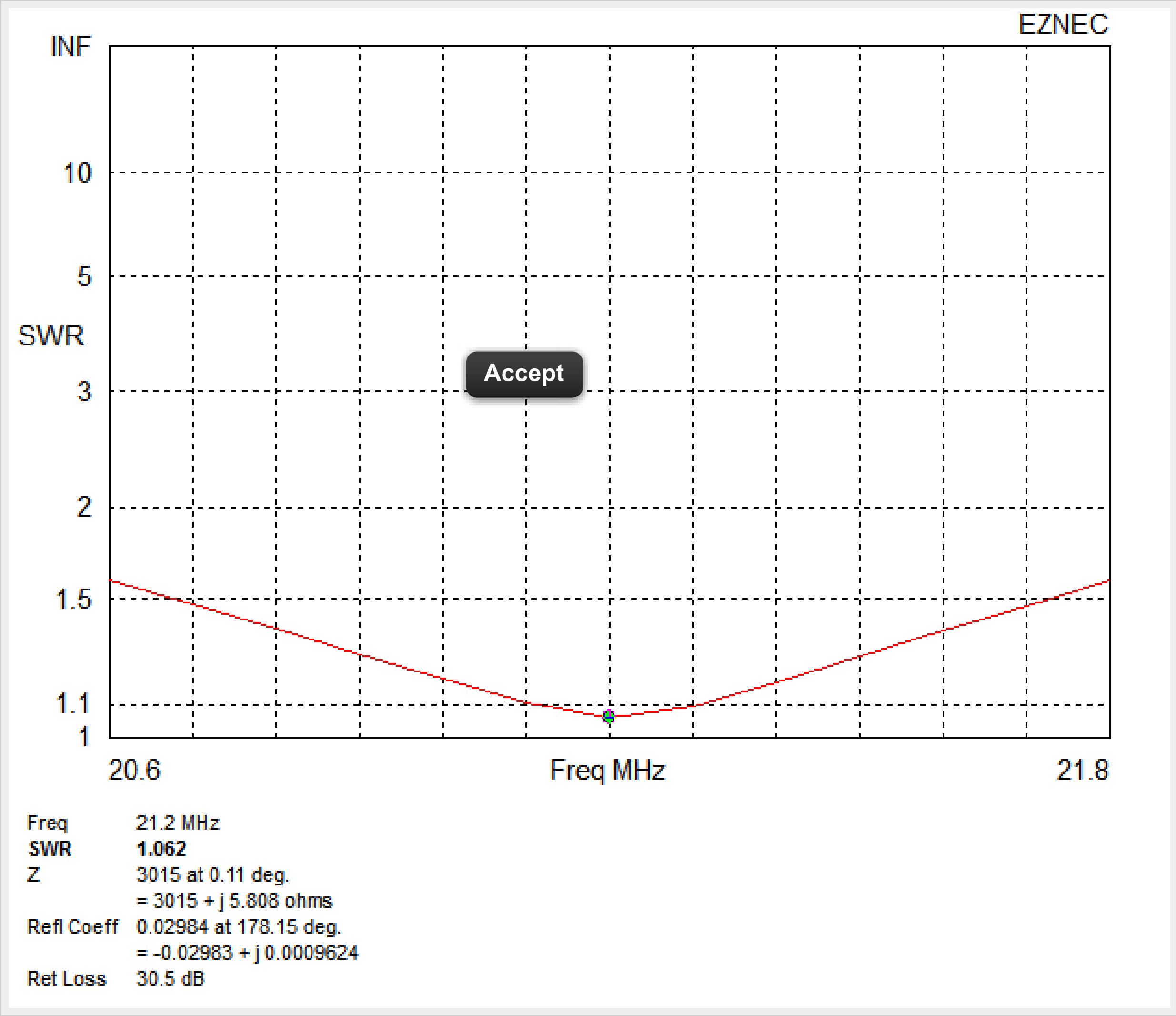
End Fed Half Wave Antenna Coupler

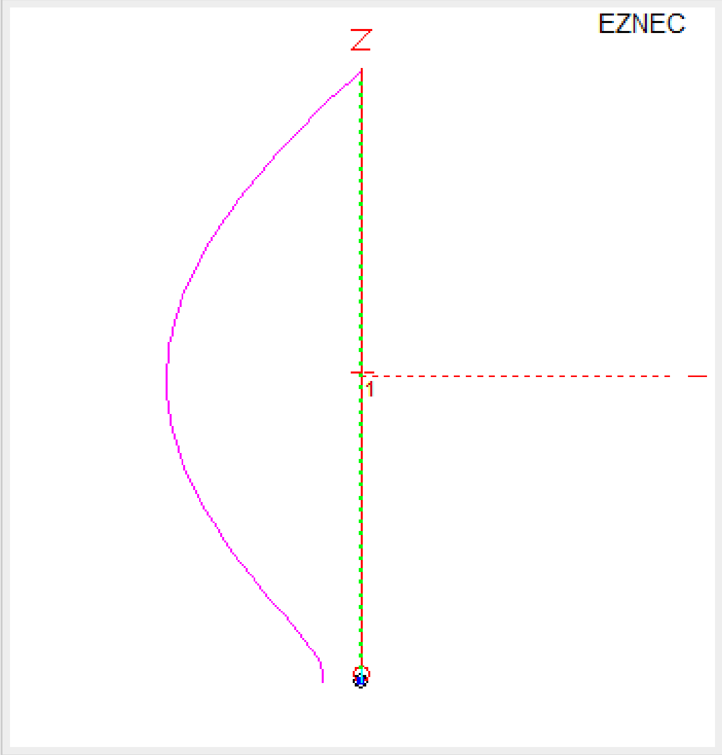




21.25

Calculate


EZNEC
INF
10
5
SWR
3
2
1.5
1.1
1
20.6
Freq MHz
21.8
Freq 21.2 MHz
SWR 1.062
Z 3015 at 0.11 deg.
= 3015 + j 5.808 ohms
Refl Coeff 0.02984 at 178.15 deg.
= -0.02983 + j 0.0009624
Ret Loss 30.5 dB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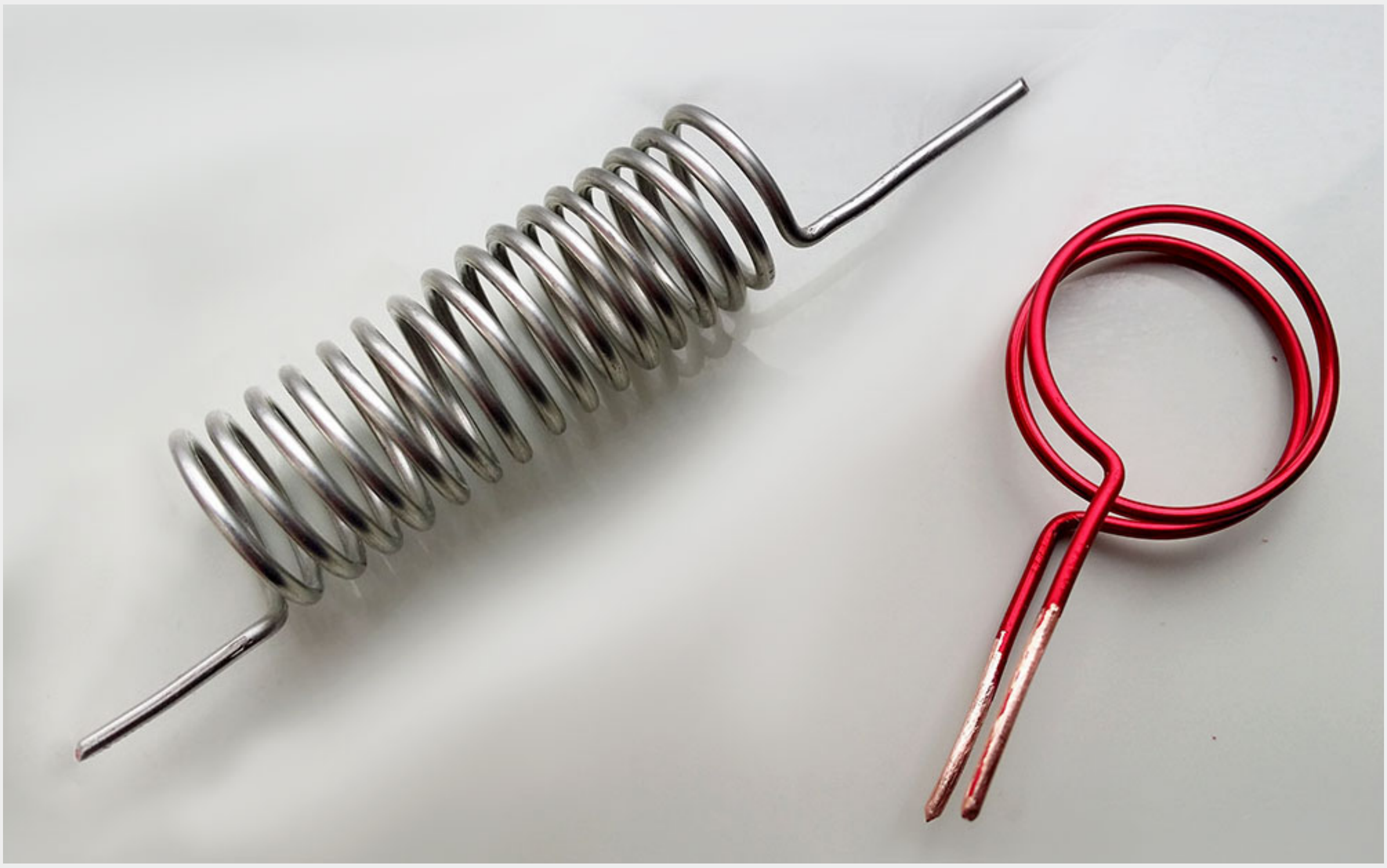
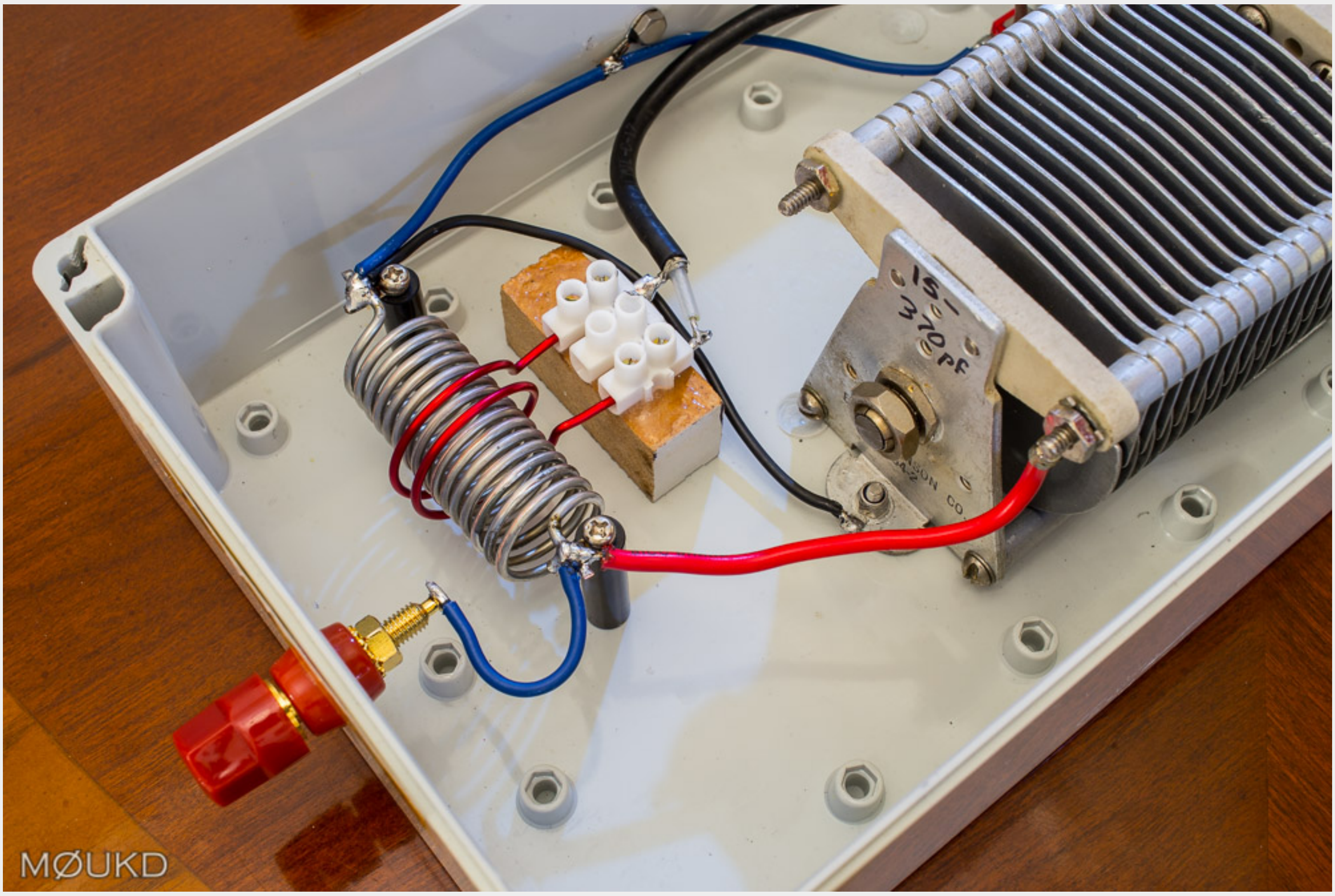


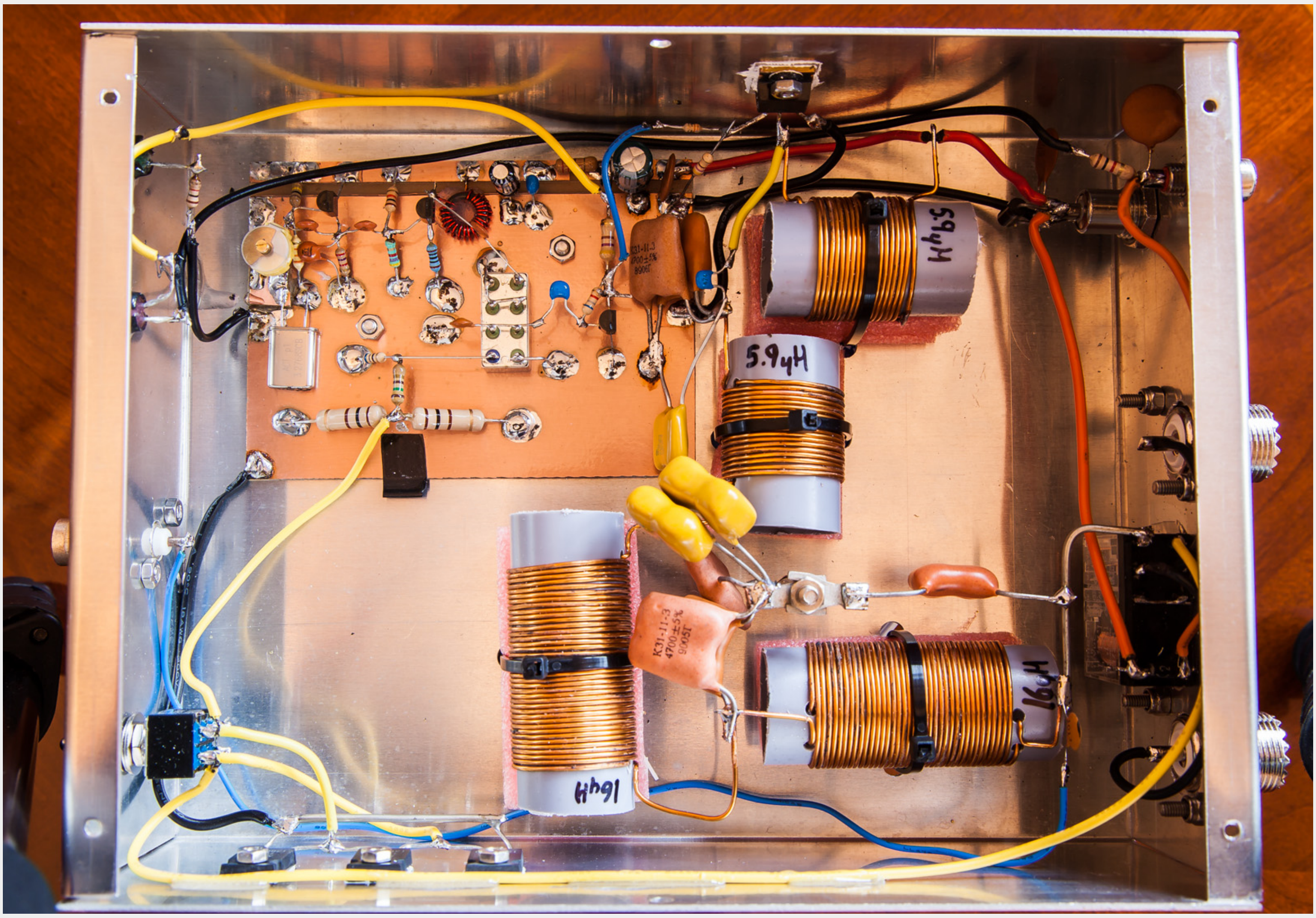

MØUKD
15-
370pF


MØUKD

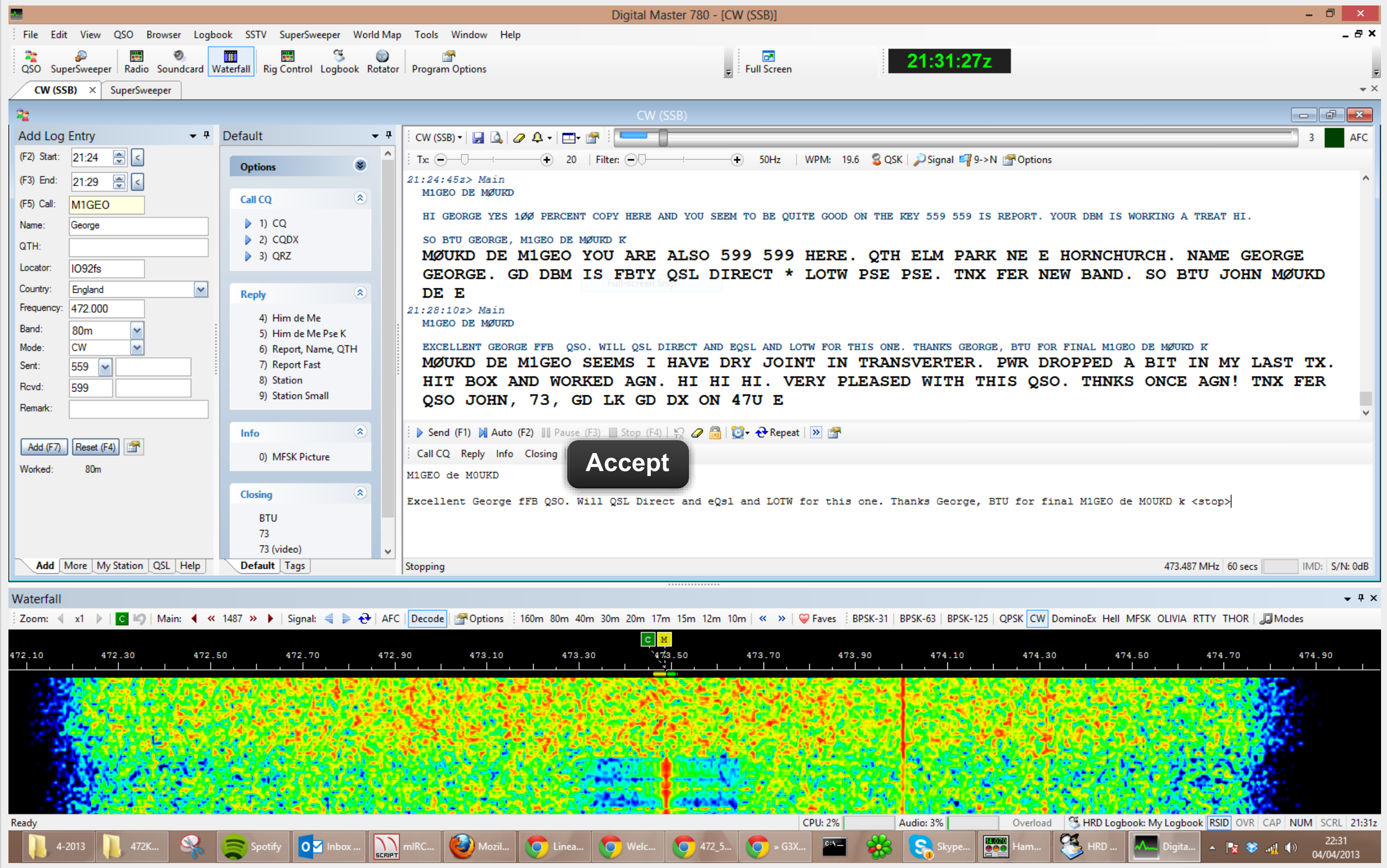

DANGER!
High Voltage RF!
MØUKD

G3XBM 472kHz Transverter


472kHz OUT
3748.5kHz IN
PTT
13.8v


5.9μH
5.9μH
16μH
16μH


Topward
FREQUENCY COUNTER 1208
G3XBM 472kHz Transverter - M0UKD
ON
TX
500mW
Input
8W
ICOM IC-7400
HF/VHF TRANSCEIVER



Spot Database

Specify query parameters

14 spots:

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2013-04-05 00:46	M0UKD	0.475638	-9	0	JO01cm	0.01	G0VQH	JO02fe	76	13
2013-04-05 00:46	M0UKD	0.475641	-20	0	JO01cm	0.01	PA0RDT	JO11tm	236	89
2013-04-05 00:46	M0UKD	0.475649	-21	0	JO01cm	0.01	PA1GSJ	JO22da	286	77
2013-04-05 00:46	M0UKD	0.475639	-10	0	JO01cm	0.01	M0ELS	JO01gn	24	79
2013-04-05 00:32	M0UKD	0.475640	+9	0	JO01cm	0.01	G8OCV	JO01cn	5	0
2013-04-05 00:18	M0UKD	0.475641	-20	0	JO01cm	0.01	PA0RDT	JO11tm	236	89
2013-04-05 00:18	M0UKD	0.475649	-19	0	JO01cm	0.01	PA1GSJ	JO22da	286	77
2013-04-05 00:18	M0UKD	0.475638	-10	0	JO01cm	0.01	G0VQH	JO02fe	76	13
2013-04-05 00:12	M0UKD	0.475638	+9	0	JO01cm	1	G8OCV	JO01cn	5	0
2013-04-05 00:04	M0UKD	0.475637	+10	1	JO01cm	1	G8OCV	JO01cn	5	0
2013-04-05 00:04	M0UKD	0.475636	-8	1	JO01cm	1	G0VQH	JO02fe	76	13
2013-04-05 00:04	M0UKD	0.475639	-19	1	JO01cm	1	PA0RDT	JO11tm	236	89
2013-04-05 00:04	M0UKD	0.475637	-9	1	JO01cm	1	M0ELS	JO01gn	24	79

Query time: 0.001 sec

A 375 Meter / 800 KHz Spark Transmitter On The Air

September, 2006

Submitted by Ken Beck, WI7B

Experimental radio history was achieved on September 30th when a team consisting of NY7T (Jim), WM7R (Pam), and WI7B (Ken), ended experimental efforts with WC9XLG (eXperimental Longwave spark Gap), a 375 meters spark gap station in Eastern Washington State.

WC9XLG was the callsign of an Special Temporary Authority (STA) granted by the FCC OET for the use of a spark gap transmitter on 800 KHz (800 AM broadcast band).

"Team Marconi 2006" utilized the transmitter to compare the sensitivity of 19th Century coherer technology to modern reception techniques. The spark gap transmitter they constructed was technically similar to that used by Marconi and Fleming at Poldhu, Cornwall in 1901 to bridge the Atlantic.

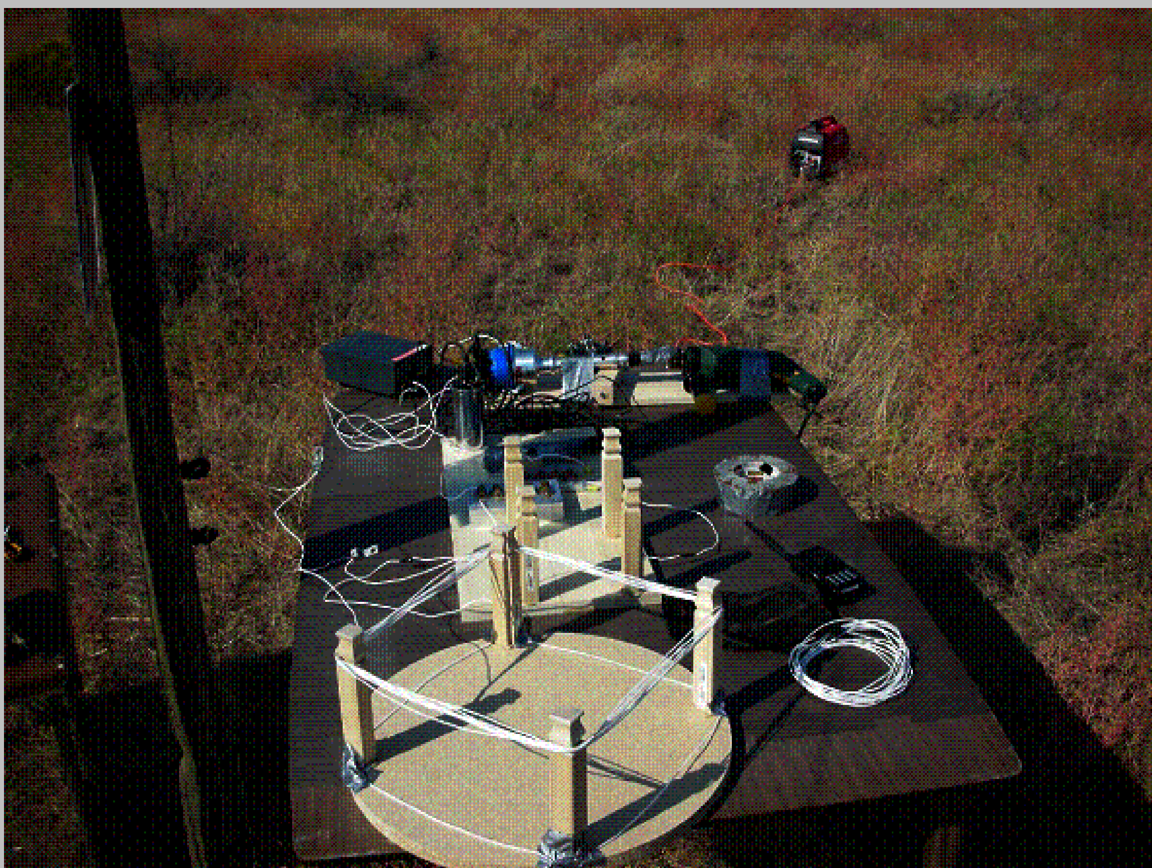

Figure 1 - WC9XLG 375 meter (800 KHz) spark gap transmitter.

WC9XLG (Figure 1) was a rotary-type spark gap based on a single-point V-8 engine distributor and spark coil. The distributor was driven by a multi-speed electric drill with all 8 distribution wires tied together to form one pole of the spark gap (Figure 2). In order to limit the possibility of interference to

broadcast stations, WC9XLG was authorized to use horizontal quarter wave Marconi antennas placed 2-3 meters above ground for both transmission and reception (Figure 3) and limited to 1 W ERP.

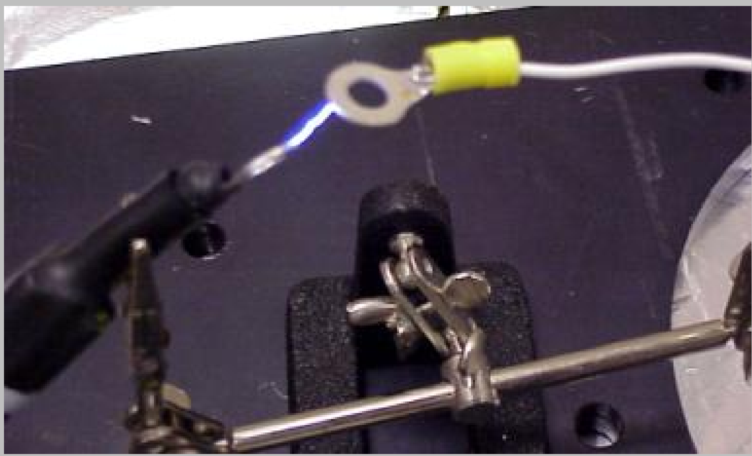

Figure 2 -Testing for a contiguous spark with an optimized (and legal) bandwidth.

Figure 3 - The tuned antenna system. The transmitter on the right, the receiver on the left.

Figure 4 - Checking the transmitter frequency.

This is the first experimental spark gap transmitter authorized by the FCC on 375 meters, and the first legally operated since 1912.

In the application for the STA, WI7B states the intention for the request as part of an effort to duplicate Marconi’s 1901 trans-Atlantic feat by using: “unsophisticated receivers, including a replica of the famous Marconi “Italian Navy” or “Bose” coherer to receive AM broadcasts.

To design a sufficiently sensitive Italian Navy coherer it is necessary to optimize the design and construction using pulsed, dampened waveforms. The coherer was utilized in the early days of radio to specifically receive spark gap (dampened wave) excitations. By using a low ERP spark gap transmitter (<1 watt) of emission type X0N, I will be able to optimize the design and construction of a coherer that will be usable to intercept and receive AM broadcasts.”

The coherer was utilized in the early days of radio to specifically receive spark gap (dampened wave) excitations. This was the normal method of receiving radio signals in 1901. In its most usual form, the coherer consists of a mass of metal filings lying in a small air gap between two metal plugs fitted tightly into a glass tube. One plug is connected to the receiving antenna, the other to earth. On reception of an RF pulse, the filings coherer moves to a low resistance state. Marconi refined the filings coherer as a result of many careful experiments. The Italian Navy coherer is a further development involving adding a small drop of mercury or carbon particles to the metal filings and using one plug composed of carbon. The phenomenon involves the breakdown of the thin oxide layers on the surfaces of the metal to form a good metal-to-metal contact. In essence, the coherer is the first solid state rectifier. A good technical description of the electronic properties of the Italian Navy coherer is provide by V.J. Phillips (The “Italian Navy Coherer” Affair: A Turn-of-the-Century Scandal”, PROCEEDINGS OF THE IEEE, VOL. 86, NO. 1, JANUARY 1998).

To design a sufficiently sensitive Italian Navy coherer (which uses a mercury drop as the auto-cohering material) it was necessary to optimize the design and construction using 800-820 KHz RF radiation. In one series of bench tests, the sine wave output of an RF generator was used in a closed circuit (no RF emissions from the circuit) to analyze the sensitivity of different metal/metal oxide compositions and grain sizes to medium frequency RF energy. Promising prototype coherers were employed to receive nearby AM broadcast stations and judged for selectivity with various matching antennas configurations.

Little research has been done into coherer reception of AM radio signals. Some experiments were carried out in 1974 by G. L. Grisdale at the Marconi laboratories in the UK. However, these have never been completely documented. What is known (as reported by V.J. Phillips) is the Grisdale attempted to use the Italian Navy coherer as a diode envelope detector for the reception of AM signals and to compare its action with that of a germanium point contact diode. His conclusion was that it would indeed rectify, but very inefficiently. However, up to now recent research had been conducted that characterizes coherer reception of damped waves versus continuous waves, or of modern digital modes for communication. Thus, one important aspect of the research program on the Italian Navy coherer was to gain an understanding of the differences between its receptions of damped waves as opposed to continuous, modulated waves.

WC9XLG proved a partial success. The team clearly received reception of the spark gap signal on 800 KHz over a distances of 30 meters (the distance separating the transmit and receive antennas) using both a metal filing coherer and Italian Navy coherer, although auto-coherence was not achieved. Based on their preliminary results, the team is already planning for a second STA to continue experimental studies next year.

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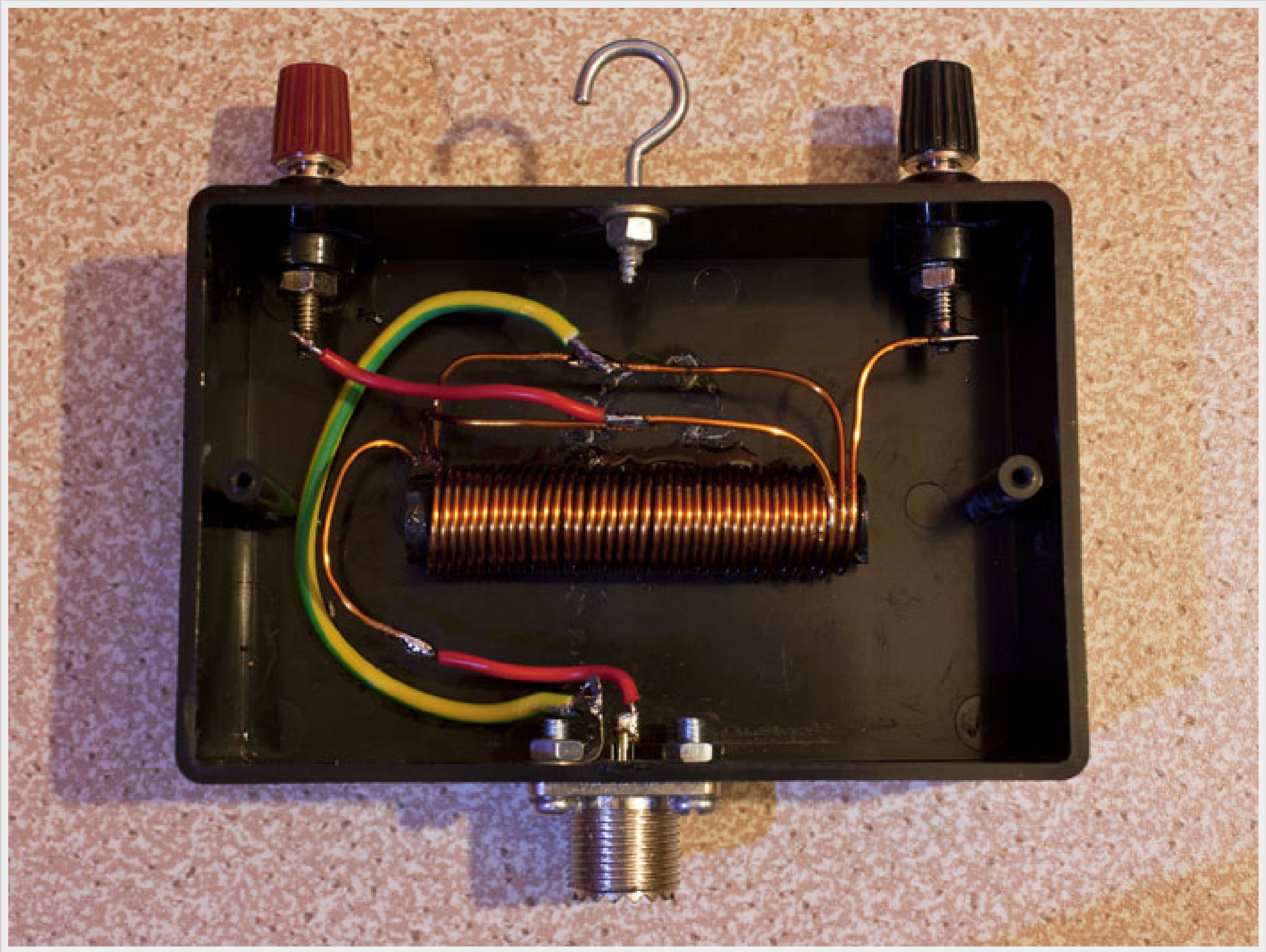
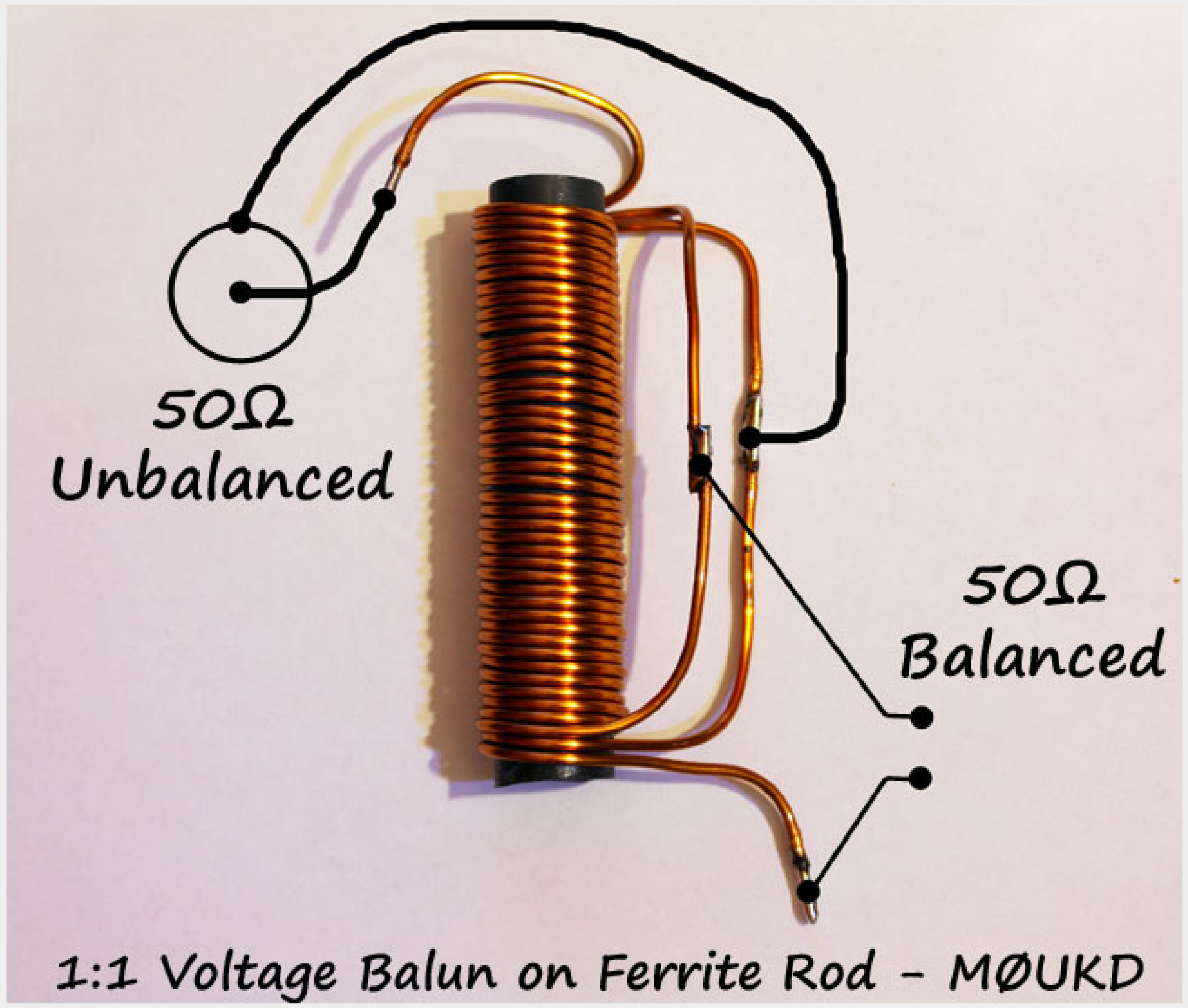
1:1 Voltage Balun for HF wire dipoles

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Unbalanced
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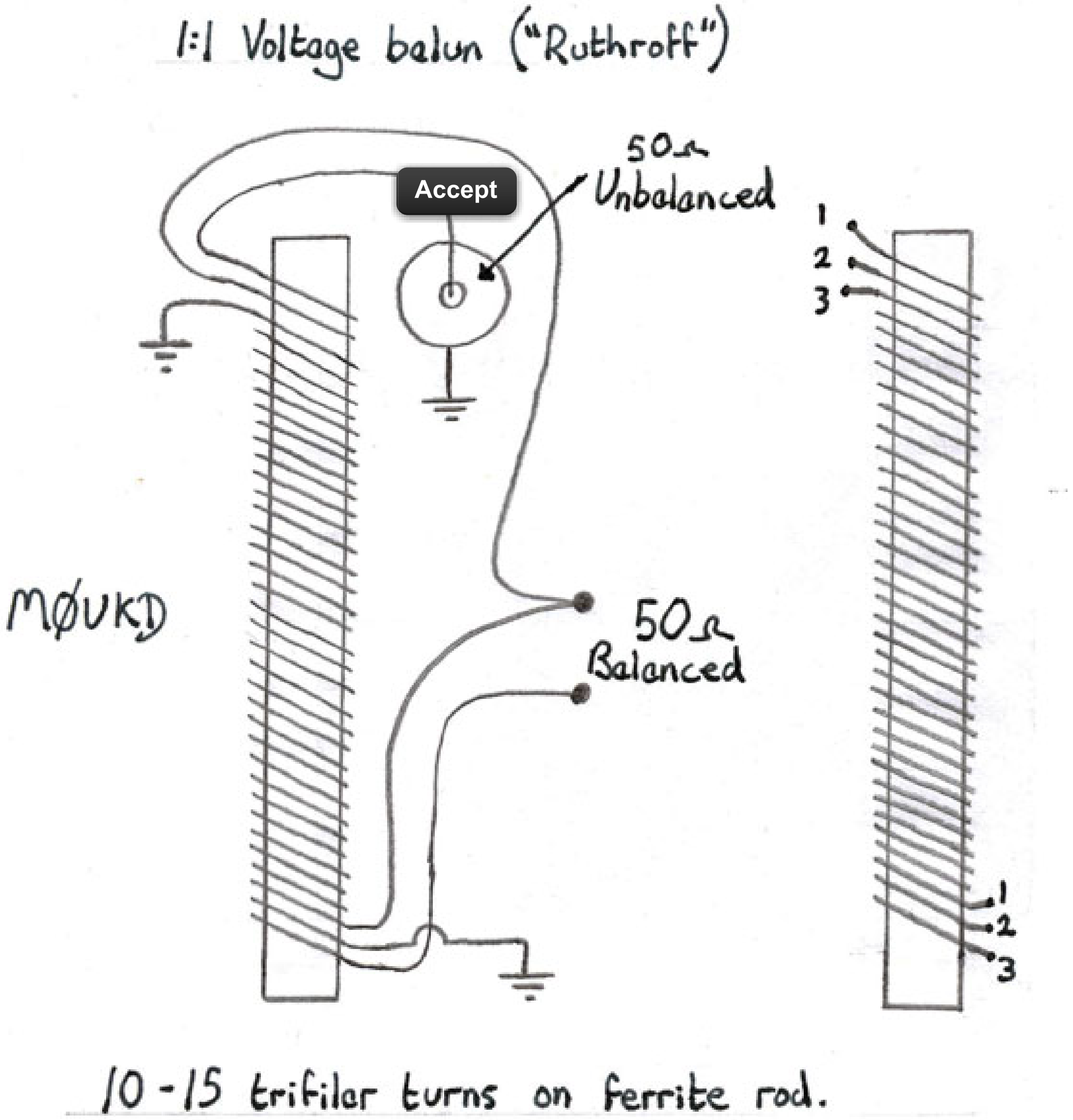
1:1 Voltage Balun on Ferrite Rod - MØUKD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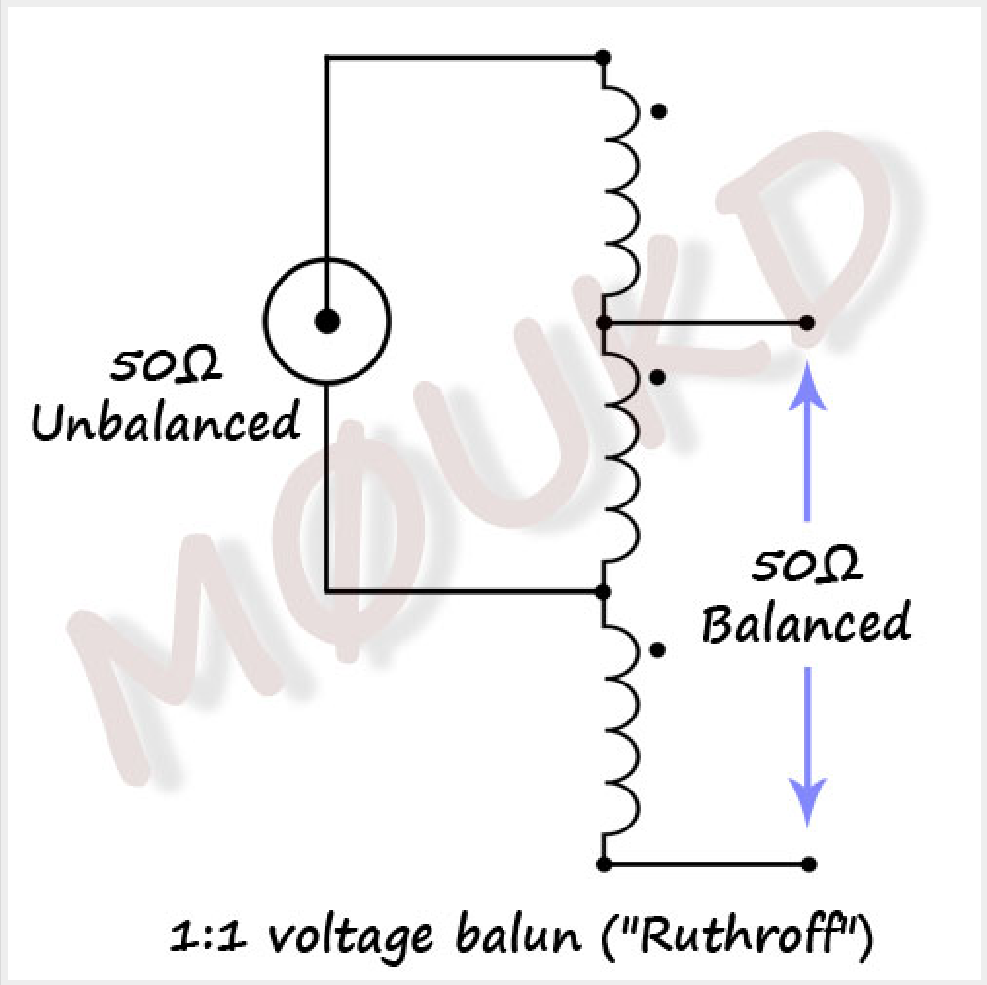
50Ω
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1:1 voltage balun ("Ruthroff")
MØUKD

Quantification of large vertical tree roots with borehole radar

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Imaging Tree Roots with Borehole Radar

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Abstract – **Ground-penetrating radar has been used to detect and map tree roots using surface-based antennas in reflection mode. On amenable soils these methods can accurately detect lateral tree roots. In some tree species (e.g. *Pinus taeda, Pinus palustris*), vertically orientated tap roots directly beneath the tree, comprise most of the root mass. It is difficult if not impossible to vertically delineate these roots with surface-based radars. To address this problem, a collaborative project between the USDA Forest Service, Southern Research Station, Radarteam AB and the Swedish University of Agricultural Sciences (SLU), was undertaken in August 2003 to assess the potential of high-frequency borehole radar to detect vertical, near-surface reflectors (0-2 m) resulting from tree roots. A set of controlled experiments on buried logs were used to test the efficacy of crosshole and borehole to surface travel time data to model near surface woody targets with tomography. Using these results, five *Pinus sylvestris* trees were scanned with borehole to surface radar and tomograms of their root systems were created. Three of the five tomograms compared favorably with root distribution maps made using destructively sampled data. However, the other two trees were misinterpreted, one was sharply underestimated, the other overestimated. This is the first report of using borehole radar to study vertical tree roots. Crosshole tomography provided excellent information on the depth of tree roots, but was less useful for imaging near surface features. Borehole to surface measures provided the best information on the near surface, where the bulk of roots are found (0-0.3 m). The technique has promise in forest research, but the development of new high-frequency borehole antennas, and forward modeling software that allows concurrent processing of travel-time and amplitude data is necessary to further this research.**

Keywords – **tomography, borehole, crosshole, *Pinus sylvestris*, root mass, root distribution, tree, root, GPR**

I. INTRODUCTION

Ground-penetrating radar can be used to detect tree roots provided there is sufficient electromagnetic contrast to separate roots from soil [1]. Forest researchers need root biomass, distribution and architecture data to assess the effects of forest management practices on productivity and resource allocation in trees. Ground-penetrating radar is a non-destructive alternative to laborious excavations that are commonly employed. Tree roots are not ideal subjects for radar studies; clutter from non-target materials can degrade the utility of GPR profiles. On amenable soils, rapid root biomass surveys provide valuable information in a short period time, though some destructive ground-truthing is required [2]. The location of larger tree roots can be mapped if there is sufficient time for intensive grid sampling. Processing 3D representations of tree roots is computationally intensive, but will become more prevalent as software advances are made to automate these procedures.

Surface-based GPR can provide excellent resolution of lateral roots. However, some forest trees have a significant allocation to large vertical taproots roots (i.e. loblolly pine, *Pinus taeda* L., longleaf pine, *Pinus palustris* Mill.), which cannot be accurately assessed by surface measures. Borehole radar allows investigation of vertically oriented targets and resolution is unaffected by depth. In reflection mode, the transmitter and receiver are lowered into a borehole and an electromagnetic pulse is propagated. The energy moves through the profile until it contacts a region with different electromagnetic properties. A portion of the energy is transmitted back to the receiver in a manner similar to conventional to surface-based radar [3]. In transmission mode, the transmitter and receiver are separated and located in opposite boreholes or placed on the soil surface. By varying the depth or surface locations a variety of ray paths can be created [3]. The simplest variable to measure and model is travel time between the antennas, though accuracy may be increased by monitoring secondary and tertiary arrivals, monitoring amplitude or advanced migration techniques [4]. A collaborative project between the USDA Forest Service, Southern Research Station, Radarteam AB and the

Swedish Experimental Forest system was undertaken in August 2003 to assess the potential of high-frequency borehole radar to detect vertical near surface reflectors (0-2 m) resulting from tree roots.

II. METHODS

2.1 Study Site

This research was conducted near Vindeln in northern Sweden in August 2003. The study site is a naturally regenerated, uneven-aged (50-200 yr) Scots pine (*Pinus sylvestris*) stand located within the Vindeln Experimental Forest (64°14' N, 19° 46' E) in the boreal zone of northern Sweden. The climate is characterized by short growing seasons; the annual mean air temperature is only 1.3 ^{o}C. The site lies 180 m above sea level on a flat glacif-luvial plain. The soils are classified as ferric and podzolised and possess a thin humus layer. The sandy soils have eluvial and illuvial horizons which are ~ 10 cm thick and are characterized by low silt and clay contents. The overstory is dominated by Scots pine which are widely spaced. The understory vegetation is sparse and consists of low ericaceous shrubs and lichens. Five trees (*Pinus sylvestris*) whose DBH ranged from 12-37 cm were selected for study.

2.2 Data Collection and Equipment

The objective of this study was to assess the utility of borehole radar to delineate vertical tree roots and the root ball directly beneath a mature tree. At each of five test trees, a 3 m transect was established on the surface. Near the beginning of each transect, a 5 cm soil auger was used to bore to a depth of 2.5 m, the subject tree was located at the midpoint (1.5 m) and another borehole was located at the end of the transect (3 m). This configuration allowed for reflective measures from a single hole, travel time measurements between holes and borehole to surface measures. We used a 1000 MHz borehole transducer (Tubewave-1000, Radarteam AB, Boden, Sweden) along with a GSSI Sir-20 ground-penetrating radar unit (Geophysical Survey Systems Inc., North Salem, NH, USA) to collect reflective data in boreholes adjacent to trees (Figure 1). At the time of the experiment, only one TW-1000 was available. In order to make travel time measurements we configured the TW-1000 as a transmitter (Tx) and used a GSSI 900 MHz antenna configured as a receiver (Rx). This worked very well for the purposes of this study, the center frequencies of the antennas were well matched; however the dimensions of the 900 MHz antenna required us to dig a larger hole to effectively lower the Rx antenna opposite the Tx antenna. Tx was operated in single shot mode, where an electromagnetic pulse was propagated and the time it took to penetrate the soil matrix and be detected by the Rx on the opposite side of the tree was measured.

Figure 1. GSSI Sir-20 radar unit, 900 MHz antenna (left) and TubeWave-1000 (right) on opposite sides of Scots pine tree.

To allow for tomographic reconstruction of the vertical roots, a series of crosshole rays were created by raising and lowering the antennas at intervals of 5 cm. Then the antennas were moved to opposite holes and the process was repeated creating 1152 unique travel-paths per tree (Figure 2).

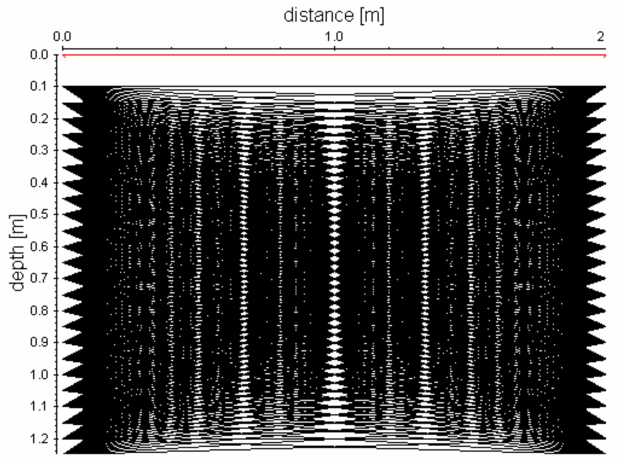

Figure 2. Crosshole ray diagram, showing 1152 unique paths.

Borehole to surface measures were collected in a similar fashion, though the Rx was moved across the soil surface (10 cm interval) and the Tx was manipulated below ground (5 cm interval), generating 2400 travel-paths per tree (Figure 3). The travel-time data sets were combined to create a master set composed of 3552 observations. We decided to limit the crosshole measures to a depth of 1.25 m to maximize overlap with the borehole to surface measures and judiciously reduce the number of manually collected observations.

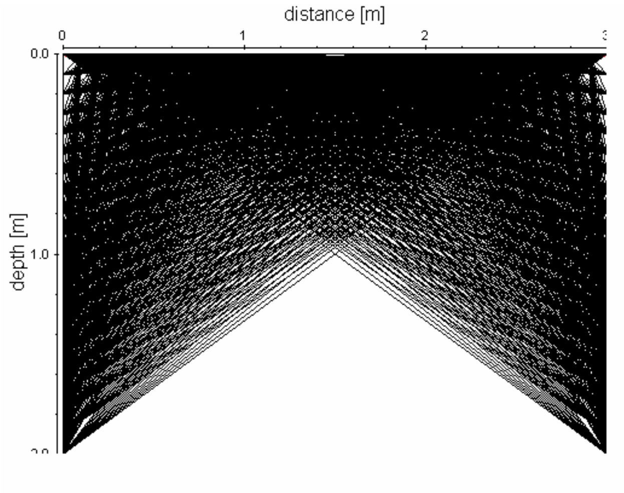

Figure 3. Borehole to surface ray diagram, showing 2400 unique ray paths

2.3 Testing Methodology

A trial run was conducted to test the sampling methods using an "artificial" tap root. Instead of a tree at 1.5 m on the transect, a large diameter soil auger was used to bore a hole to 0.8 m and a fresh cut Scots pine log (27.5 cm diameter) was inserted. Only borehole to surface measures were collected. The log was removed and a shorter log segment (40 cm) was inserted to a depth of 0.8 m and the hole was filled with soil. Both crosshole and borehole to surface measures were made. This configuration allowed a more complete delineation of the cut log since electromagnetic pulse could pass directly over the top of the target.

Figure 4. Preparing to bury a fresh cut log sections .

2.4 Data Processing and Tomography.

All data processing and modeling was preformed using REFLEXW Version 3.0 (K.J. Sandmeier, Karlsruhe, Germany). The raw data consists of travel time values and amplitudes. Version 3.0 of REFLEXW was designed to allow for tomographic modeling of travel time transmission and reflection data from GPR, ultrasound or seismic sources. It did not permit the interpretation of signal strength or amplitude in tomographic modeling mode [5]. For our study, we used the first time of arrival of the propagated electromagnetic signal and ignored any secondary or tertiary arrivals which may have taken a more circuitous path than those in the ray diagrams (Figures 2 and 3). It was necessary to create a "pick" file which determines the first arrival time for a given ray and compile this data to be interpreted by the tomography model. A number of different analysis models were attempted to interpret the travel time data. The best agreement was found with simple beam and weighted beam models. Use of curved ray models seemed to over-migrate, accurately showing the location of the object, but not size or proper shape. The end result of forward modeling was a tomogram which represents the physical properties of a two dimensional plane between the boreholes [5]. The success of this study was dependent on the tree roots having distinct electromagnetic contrast against the fine sandy soil.

2.5 Destructive Harvest of Root Systems

After the five trees were scanned with GPR, the orientation of the transect was marked on the trunk for future reference. The trees were removed from the soil using a specially designed winch system; wherein a cable was placed 15 + m up the tree and the leverage of the bole was used to topple the tree. Near the base of the tree at breast height a triangular bumper was affixed and served as a fulcrum to help dislodge the root ball without breaking the roots. Technicians at the Vindeln Experimental Forest removed the root ball and used a pressure washer to remove any remaining soil. In order to quantitatively assess the root characteristics of each tree, a strategy was devised to assess and spatially differentiate root mass. Roots directly between the boreholes likely had the greatest influence on EM travel-time, but there was no available guidance on the width of the detection zone. Based on preliminary findings with the buried root tests, we sampled 0.25 m on either side of the transect a discarded any roots outside of this area (Figure 5). The potential root volume beneath the measurement footprint (Figure 5) was differentiated by depth and distance along the transect. As roots were sampled, they were assigned a cell number which corresponds with the diagram in Figure 6. The roots were oven dried at 55 °C for several weeks and weighed; no root size class information was collected. It was necessary to develop a projection of the root mass data between the two boreholes to compare with the tomograms. This could be achieved in a rudimentary fashion by using the 15 cells (Figure 6) versus the 100,000+ pixels in each tomogram. Instead, a modeling technique which migrated the mass of each cell

towards the tree center or nearest concentration of root mass, to differentiate the likely distribution of mass within the cell. This was achieved by sub-dividing each cell into 9 equal sized units with the identical value and running a contour analysis in SigmaPlot 2001 (SPSS, Inc.).

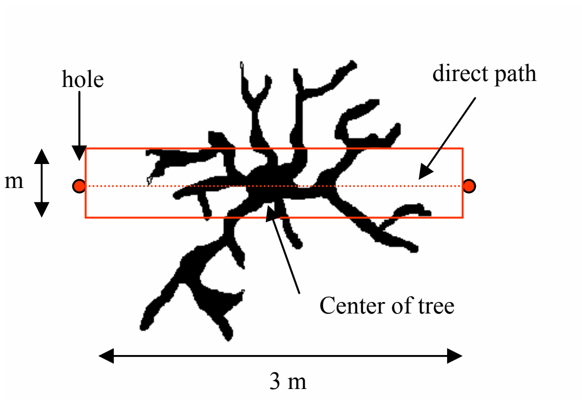

Figure 5. Aerial view of root sampling area, only roots within lines (0.5 m X 3.0 m) were collected.

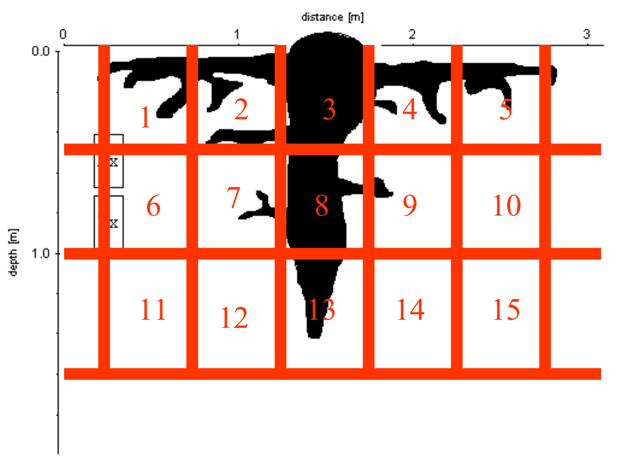

Figure 6. Diagram depicting the root mass cell matrix; each root mass cell was 0.5 m X 0.5 m X 0.5 m.

III. RESULTS

3.1 Buried Log Tests

Initial work with TW-1000 in reflection mode was difficult to interpret. Much like surface-based high frequency GPR, reflectors close to the antenna were well defined, but resolution was limited by horizontal penetration. This was problematic when scanning near the base of a large tree with many interconnected roots. We did not have access to pulley mounted survey wheel which would have made the metering of pulses more accurate. The use of reflection borehole GPR was discontinued and the focus was placed on crosshole and borehole to surface measures.

The crosshole data modeled with REFLEXW accurately defined the vertical limits of the 0.4 m buried log (Figure 7A), demonstrating that the fresh cut log is a suitable target for GPR in this soil type. The horizontal location of the log along the transect was not resolved with crosshole tomography. The crosshole measurements were collected to a depth of 1.25 m, which is deeper that most roots would penetrate. However, when the Rx and Tx were offset vertically there were few ray paths that were unaffected by the position of the log; only those with minimal slope could trace the margins of the target.

The borehole to surface data created a tomogram which effectively located the buried log along the horizontal plane (Figure 7B), yet was less capable of defining the vertical margins of the log. Figure 7B, shows a bias towards the right side of the tomogram which seems to pull the predicted location of the log to the right. It is not known if there were any other reflectors inducing clutter near the bottom of the borehole, but it would be unlikely in this soil. Other explanations include: poor transmission from the bottom of the borehole to the furthest extent of the transect, the bottom of the log may have been slighted tipped, presenting a more resistive surface to the EM pulse, or the soils on the right side of the diagram exhibited different electrical properties which affected the EM travel time. When the data sets were combined there was a moderation of the biases noted in the individual data sets (Figure 7C). The depth of the buried log is more accurate than using the borehole to surface data alone. The bias towards the right side of the diagram remains, but is minimized.

The 1.2 m log (buried to 0.8 m) was intended to simulate conditions as would be found with large vertical tap roots, with the caveat of not having direct Rx access to the surface where the log protrudes from the ground. Considering the results of the 0.4 m log test, and the time required to manually collect thousands of single shot EM transmissions, only borehole to surface data were collected. The resulting tomogram approximated the shape of the 1.2 m log (Figure 8), though similar to the 0.4 m log test (Figure 7B), there was a strong bias to the borehole on the right. Both log lengths were measured using the same auger hole and boreholes, so any soil effects would be similar. The modeled log in Figure 8 shows some distortion near the surface creating a cross-shaped pattern, which was not observed in the previous test. Shallow soil depth combined with the log protruding from and disrupting the soil surface may be reducing the quality of the signal transmission. The effect is exaggerated by the lack of 7-8 ray paths which cannot be sampled due to the protruding log.

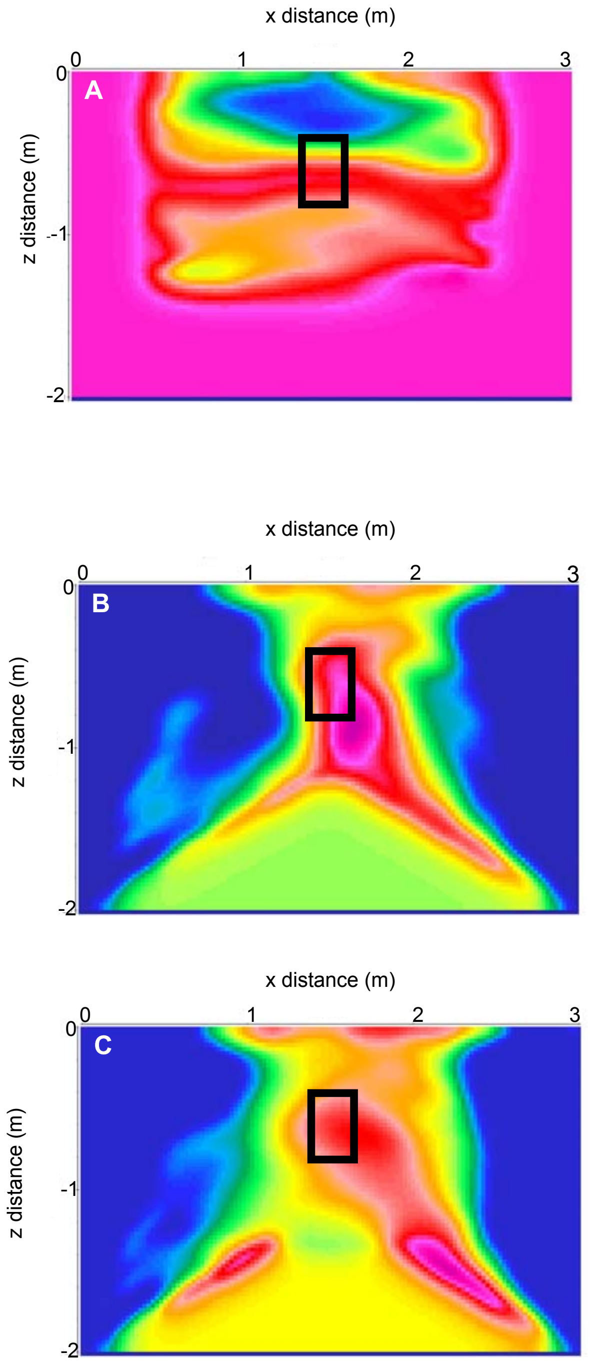

Figure 7. Tomograms from the 0.4 buried log test m (actual location marked in black) modeled using A) crosshole only data, B) borehole to surface data and C) combined crosshole and borehole to surface data (x =0 to 3 m, z= 0 to -2 m).

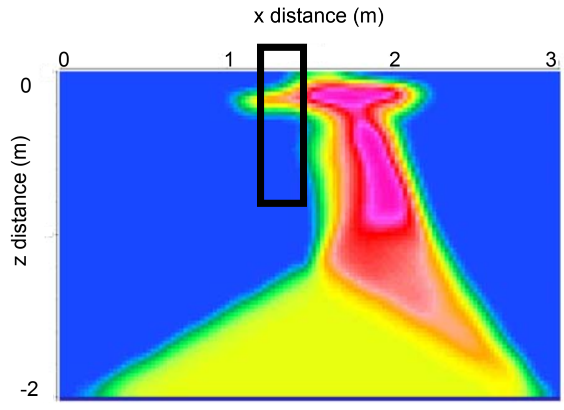

Figure 8. Tomogram from the 1.2 m buried log test m (actual location marked in black) modeled using borehole to surface data (x =0 to 3 m, z=0 to -2 m).

3.2 Tree Analysis

Each of the trees was scanned using the borehole to surface sampling scheme in Figure 3, and modeled with REFLEXW to produce the tomograms in Figure 9. The array of model options in reflex are quite extensive [5]. Some level of interpretation was required to choose the model parameters, but we had the benefit of the buried log of known dimensions to help parameterize the model. The model derived from the buried log tests was applied to all five trees. This was performed without prior knowledge of the destructive harvest data. Root mass collected by destructive sampling, and divided into 15 cells, was modeled to show the spatial distribution of mass and project a rooting area map on the 4.5 m^2 plane (x=0 to 3 m, z = 0 to -1.5 m) between the boreholes (Figure 9). Trees 1, 2 and 4 display a high degree of similarity between the tomograms and the root maps (Figure 9). Tree 1 shows a large mass beneath the bole, extending to either side. Directly underneath the tree is a region where root density is noticeably reduced. Tree 2 is the smallest tree, having only 5.1 kg of roots in the sampling zone (Table 1). The tomogram clearly shows that this tree has the smallest root ball and limited rooting area within the measurement plane (Figure 9). There is a bit of clutter in the tree 4 tomogram, the contours originating from the lower right side, rising to meet the root ball, will be removed from additional analysis. Otherwise, this is also a good match. Trees 3 and 5 appear to be misinterpreted by the tomogram. Tree 3 is the second smallest tree, though the tomogram shows a relatively large rooting area on the xz plane (Figure 9). The opposite condition is observed with tree 5; this large tree is interpreted as having a much smaller root ball than was found destructively.

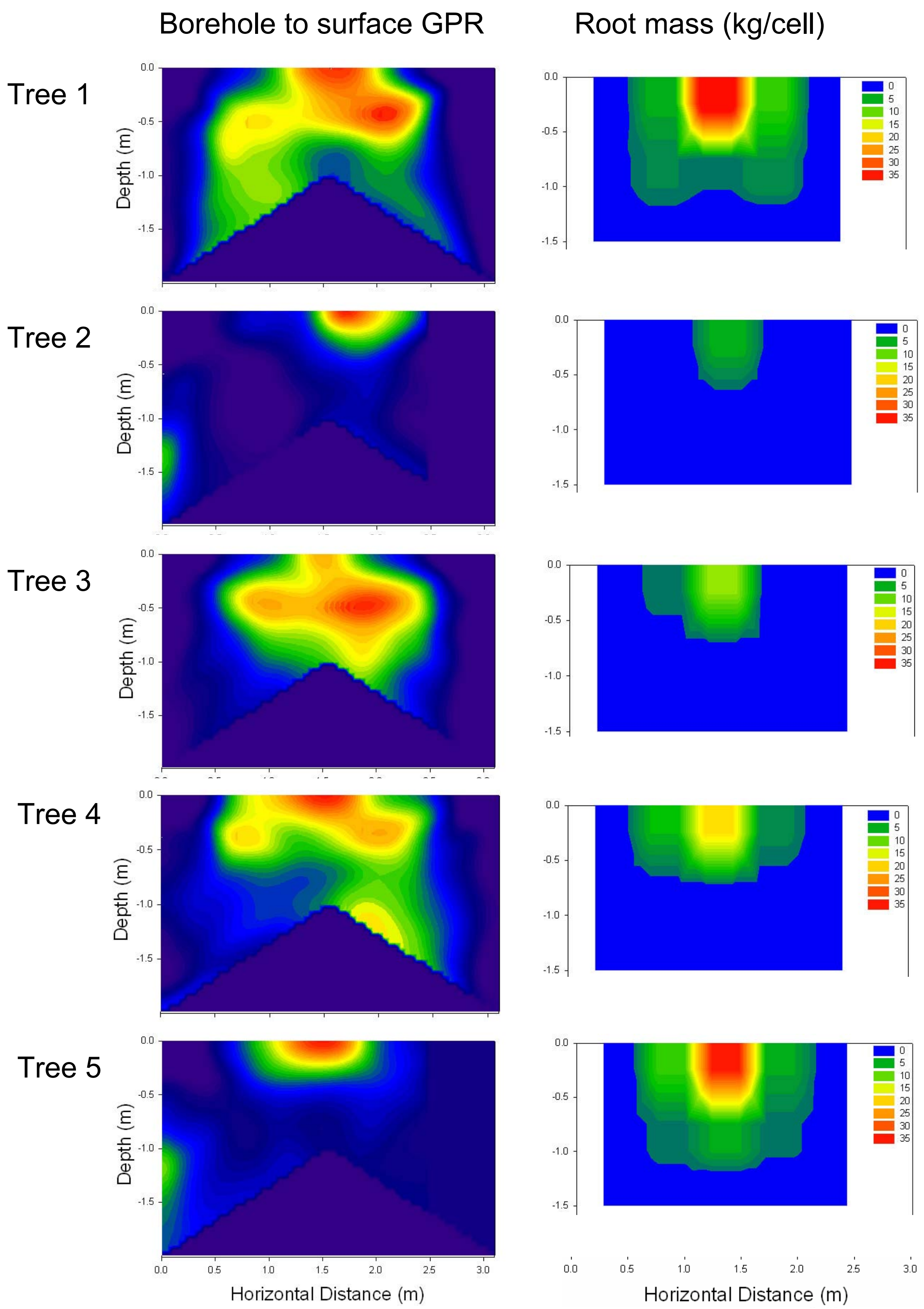

Figure 9. Comparison of borehole to surface tomography and the model of actual root mass (x =0 to 3 m, z=0 to -2 m).

Table 1. Root mass within the sampling area, diameter at breast height (DBH) and age of the five study trees.

Tree #	Root mass (kg)	DBH (cm)	Age (yr)
1	60.5	36.7	193
2	5.1	12.1	56
3	13.6	18.7	71
4	26.4	23.5	110
5	55.1	32.5	191

In order to quantitatively compare data derived from GPR and the destructive sampling, we compared the rooting area contour map created with SigmaPlot using root mass linked to spatial distribution among the cells to the total root mass harvested from each tree (Table 1). The projected rooting area on 4.5 m^2 plane between the boreholes was highly correlated to total root mass (Figure 10). In must be noted that these variables are co-related; projected rooting area is derived from the root mass in each cell. However, this does demonstrate that projected rooting area is a function of total root mass and can be used for comparison with the tomograms.

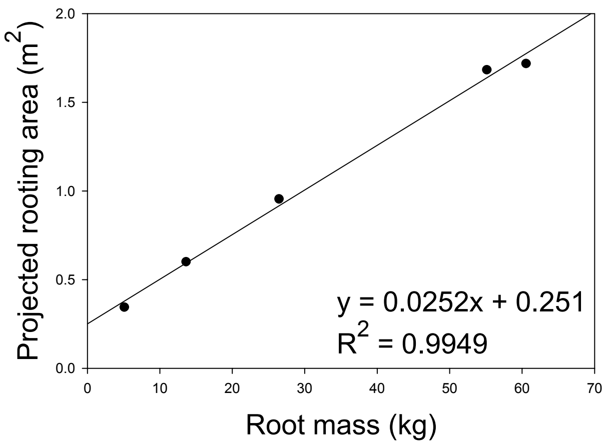

Figure 10. Projected rooting area in the 4.5 m^2 plane between the boreholes (x =0 to 3m, z=0 to -1.5m) compared to total root mass.

The relationship between projected rooting area and radar derived rooting area is rather poor (Figure 11). This is due to the misinterpretations of trees 3 and 5.

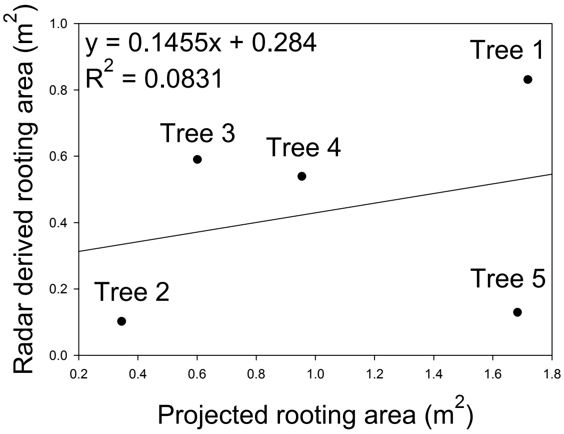

Figure 11. Projected rooting area compared with radar derived rooting area.

The application of simple allometry, which relates the relative size or growth of an easily measured tree parameter (e.g. diameter at breast height) to a parameter which is more difficult to directly sample, in this case total root mass is still superior to borehole radar results (Figure 12).

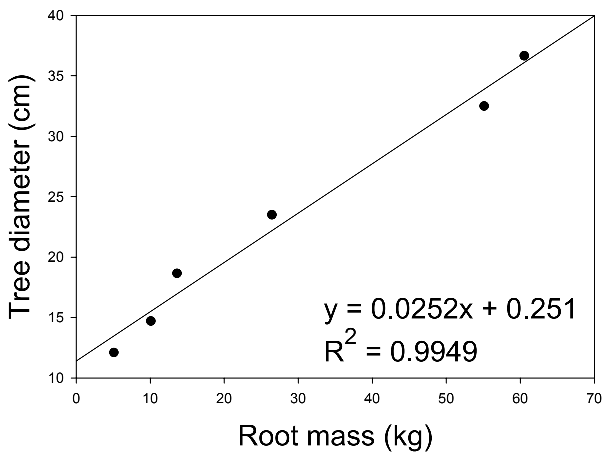

Figure 12. Comparison of tree diameter at breast height to root mass in the measurement area.

IV. DISCUSSION

This is the first report of using borehole radar to study vertical tree roots. Cross-hole tomography provided excellent information on the depth of tree roots, but was less useful for imaging near surface features. For crosshole tomography to successfully image tree root structures, the boreholes need to be deep enough to achieve the pitch necessary to resolve the mass of roots near the surface. In the case of the 0.4 m buried log, few, if any, ray path travel

times were unimpeded by the presence of the log. Borehole to surface measures provided the best information on the near surface, where the bulk of roots are found (0-0.3 m). This new application of borehole GPR worked very well on 3 of 5 trees, but clearly misinterpreted the other two trees. Based on the buried log tests, overestimation is more likely when there is a flat reflective surface at a oblique angle to the ray path, as in the case of the cut end of the buried log. Overestimation may also occur if there is a degradation of the wall of the borehole, preventing adequate contact for penetration. This is important on near surface studies where borings are in soil versus solid rock. The causes of root mass underestimation are less obvious.

Forward modeling of borehole data using REFLEXW version 3.0 software was limited to travel-time data. Inclusion of amplitude forward modeling would likely enhance mass quantification. The addition of secondary and tertiary arrivals would also help refine the interpretative value of the data [4]. It was possible to "pick" arrival times other than the first arrival in REFLEXW, however it was a manual process demanding a user to select the individual data points [5]. Considering the thousands of transmissions collected and the potential for arbitrary arrival time assignments, this was not a viable processing option.

Borehole radar has promise in forest research, but the development of new high-frequency borehole antennas, and forward modeling software that allows concurrent processing of travel-time and amplitude data is necessary to further this research. We had hoped to find *P. sylvestris* trees exhibiting well defined vertical tap roots, instead many smaller vertical roots (< 1 m) deep comprising a large "root ball" were observed. It may be valuable to use this technology to measure tap root depth in deeply rooted *Pinus palustris* trees. This would be useful to estimate belowground carbon storage in living tree organs and better understand where they acquire resources deep within the soil profile.

The Tubewave-1000 was not designed specifically for this study or for root analysis. In 2005, an improved version of the Tubewave-1000 became available; featuring a new non-dipole configuration and more sensitive Rx/Tx electronics. It could be refined to permit wave propagation from a smaller point-source, to resolve smaller targets and more accurately define the origin of the transmission. This study used extremely small sampling intervals (5 and 10 cm) which would benefit from these changes. Automation of data collection would also enhance the utility of borehole methodology. The time required to sample each tree manually was 5-6 hours. The development of self contained winch-based survey wheels, modular tracks upon which antennas could be moved on the surface and software to choreograph the antenna movements and measurements would revolutionize the applied use of this technology.

Presently allometry gives more accurate estimates of root mass than travel-time tomography, however allometric relationships are typically site and species dependent. Considerable amounts of destructive sampling are needed to parameterize equations for a given site. When experiments are conducted which alter carbon assimilation or allocation in trees, standard allometric equations cannot be assumed valid.

V. CONCLUSIONS

Borehole radar has promise in forest research, but the development of new high-frequency borehole antennas, automated data collection systems and forward modeling software that allows concurrent processing of travel-time and amplitude data is necessary to further this research.

ACKNOWLEDGMENTS

This research was supported by the USDA Forest Service, Southern Research Station, and the Swedish University of Agricultural Sciences (SLU). The technical assistance in the field was provided by Tomas Hörnlund, Otilia Johansson and Ludwig Dorfstetter. RadarTeam AB graciously provided the equipment used in this study as well as technical support (www.RadarTeam.se).

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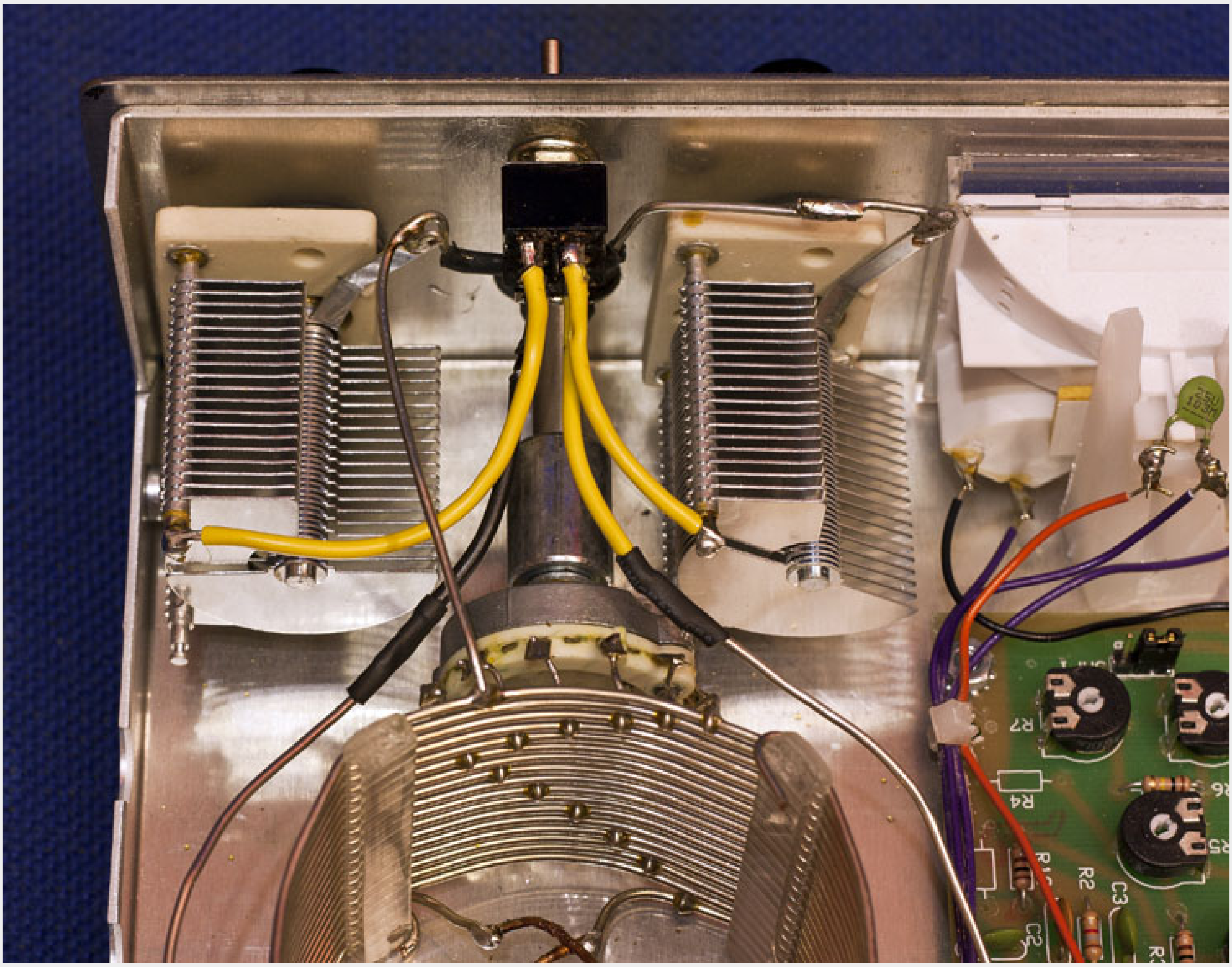
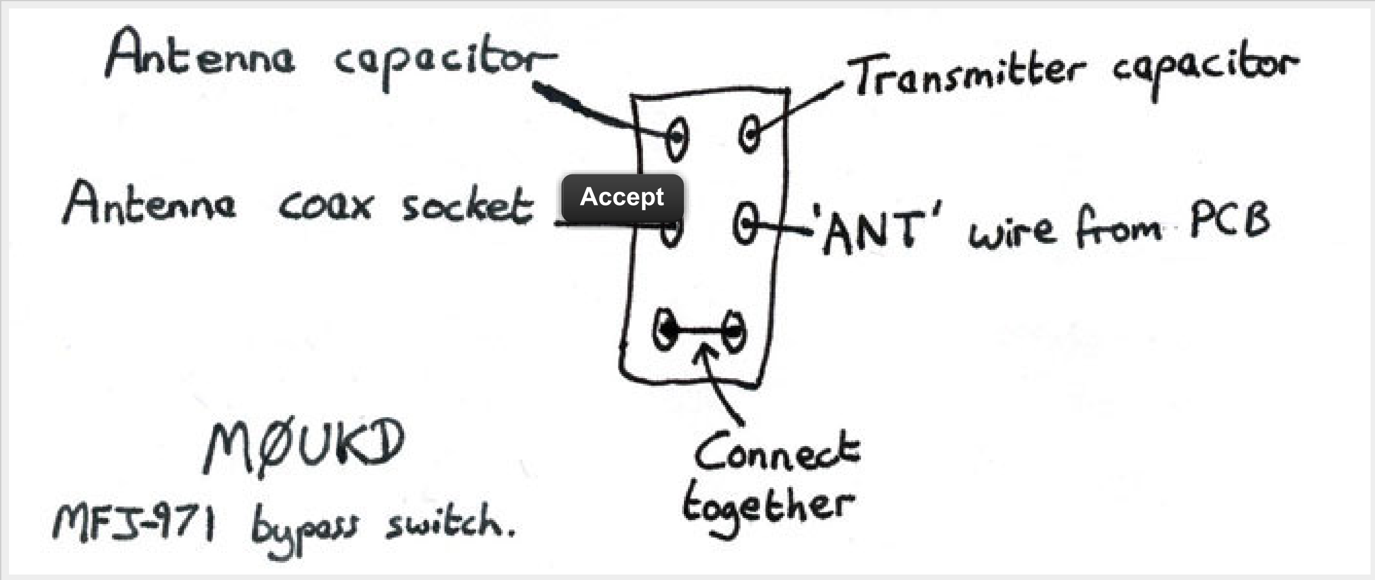
MFJ-971 Portable Antenna Tuner Modifications

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Antenna coax socket
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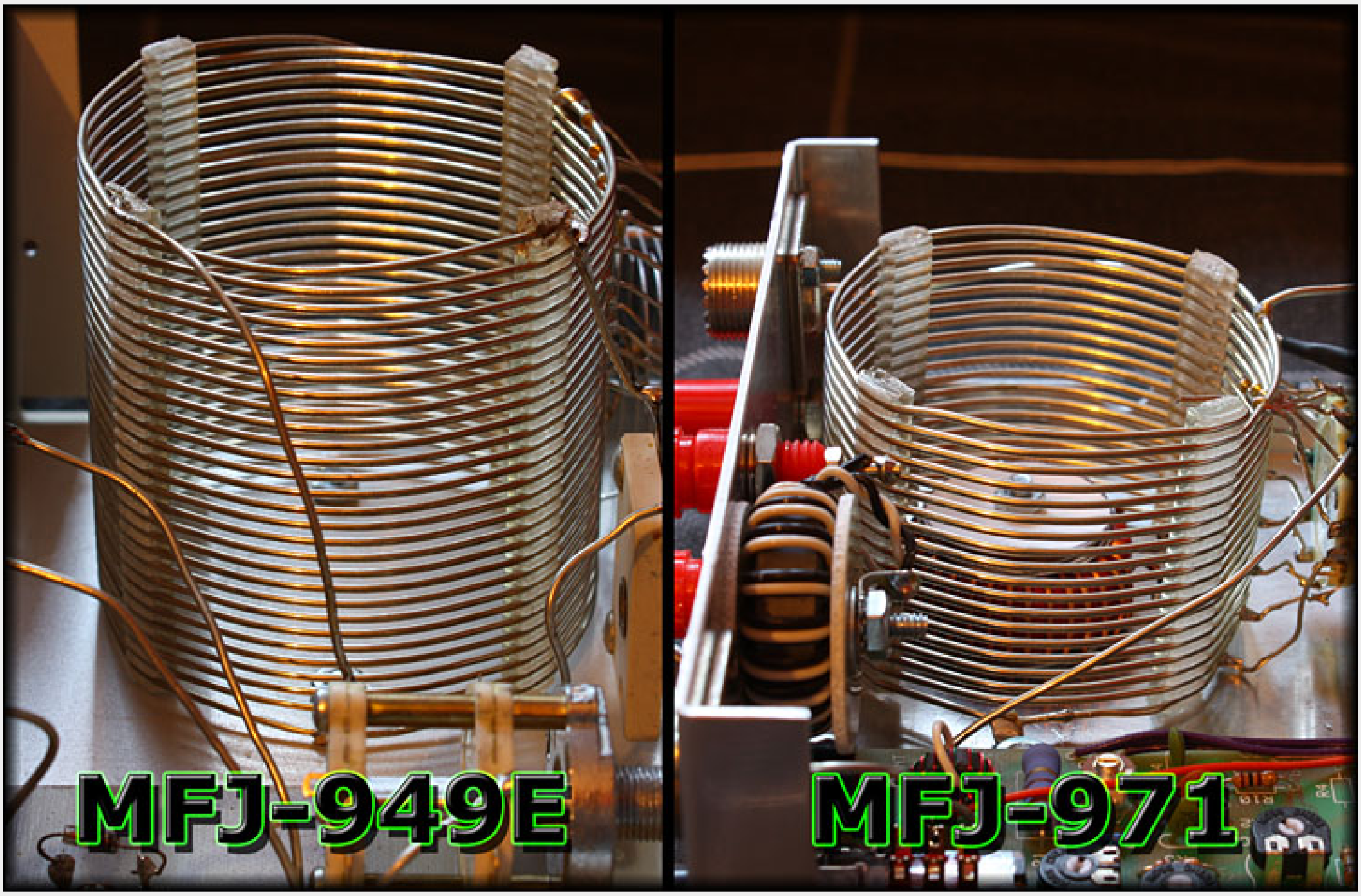
Connect together
MØUKD
MFJ-971 bypass switch.

Accept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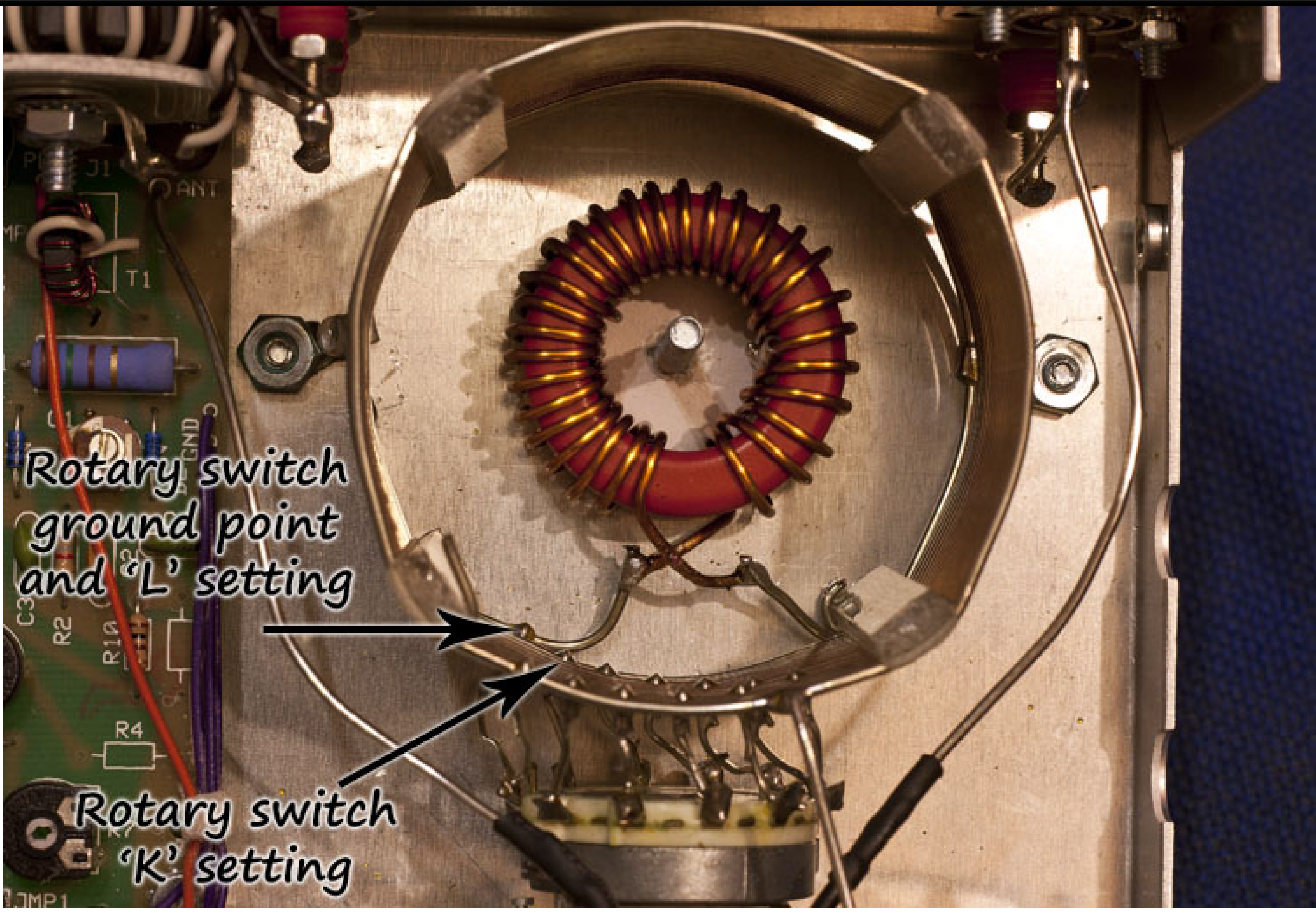
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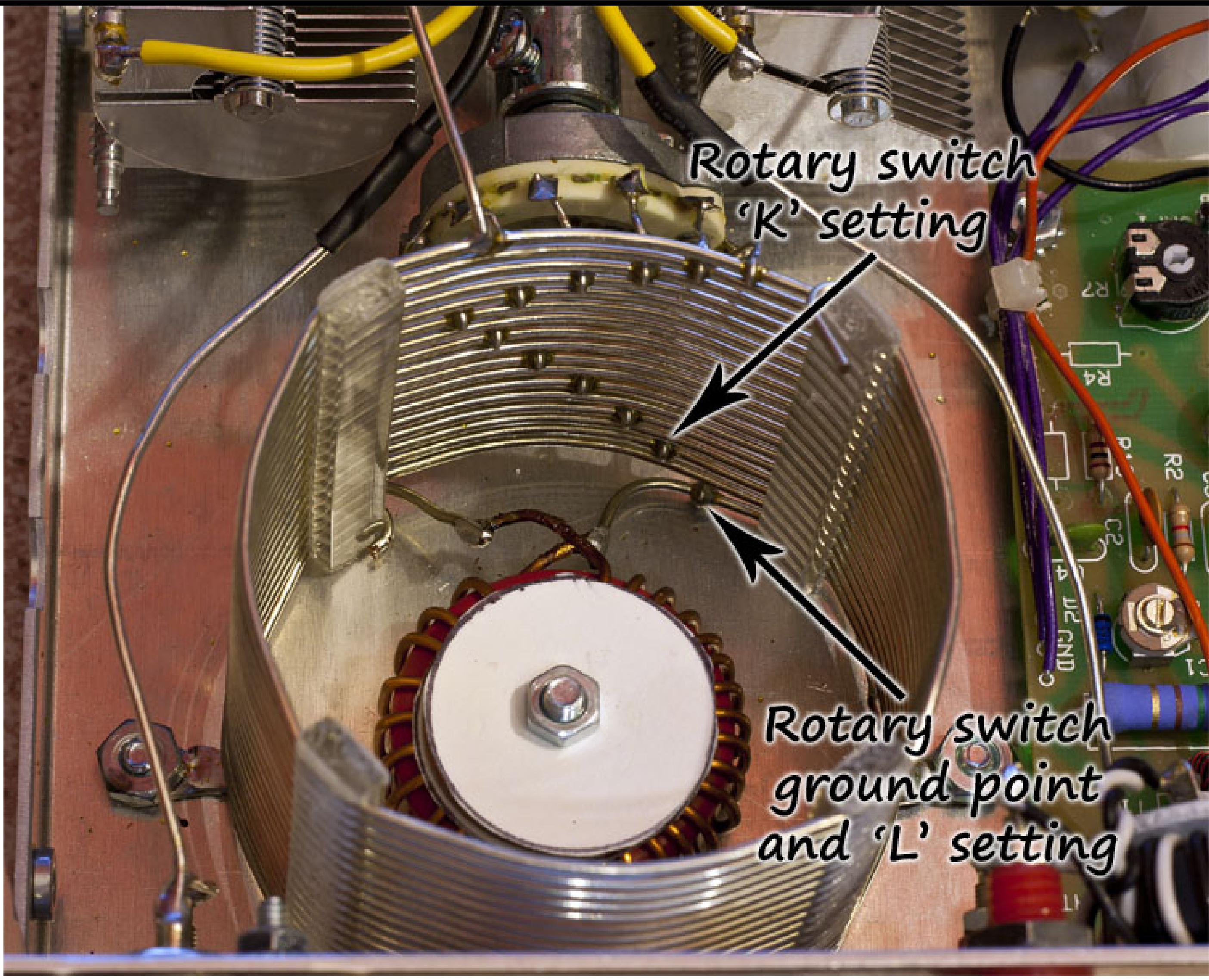
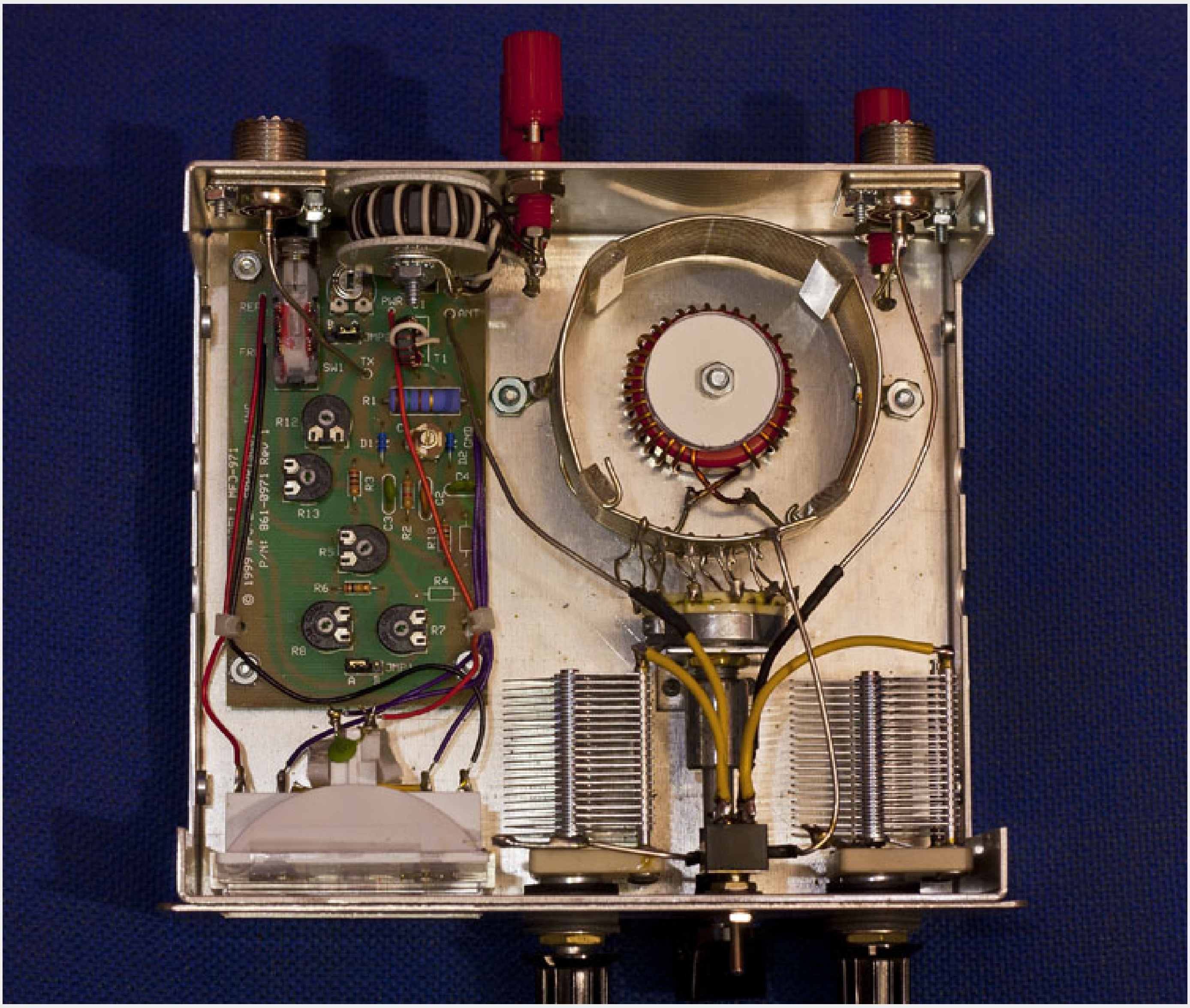
ground point
and 'L' setting
Rotary switch
'K' setting


Rotary switch
'K' setting
Rotary switch
ground point
and 'L' setting


DANGER
MFJ-971
May give you
RF Burns!



AMATEUR RADIO AF4K

AF4K's 6CL6 - 2E26 HOMEBREW TRANSMITTER

Jan 3 2004

As seen here, the rig was still under construction!

The power supply uses a mains transformer from an old Bogen P.A. amplifier. Yes, rusty but I might paint it some pretty color, ha! The full wave diode rectifier provides it with an unloaded B+ voltage of about 525V. Under load it drops to about 505V - not bad.

I am using a 6CL6 pentode as a Colpitts crystal oscillator with untuned output. In other words it has an RF choke in the plate circuit and is coupled capacitively to the 2E26 grid.
On the 6CL6 there is 220V of B+ and 120V of screen voltage.
I had to use some subs, like a 40 pF and a 330 pF instead of a 22 pF and 220 pF on the grid. But what the heck!

I plan to convert this TX to grid block keying eventually.
Right now it just has the cathodes temporarily grounded for testing purposes, so if I turn it on it is ON, period!

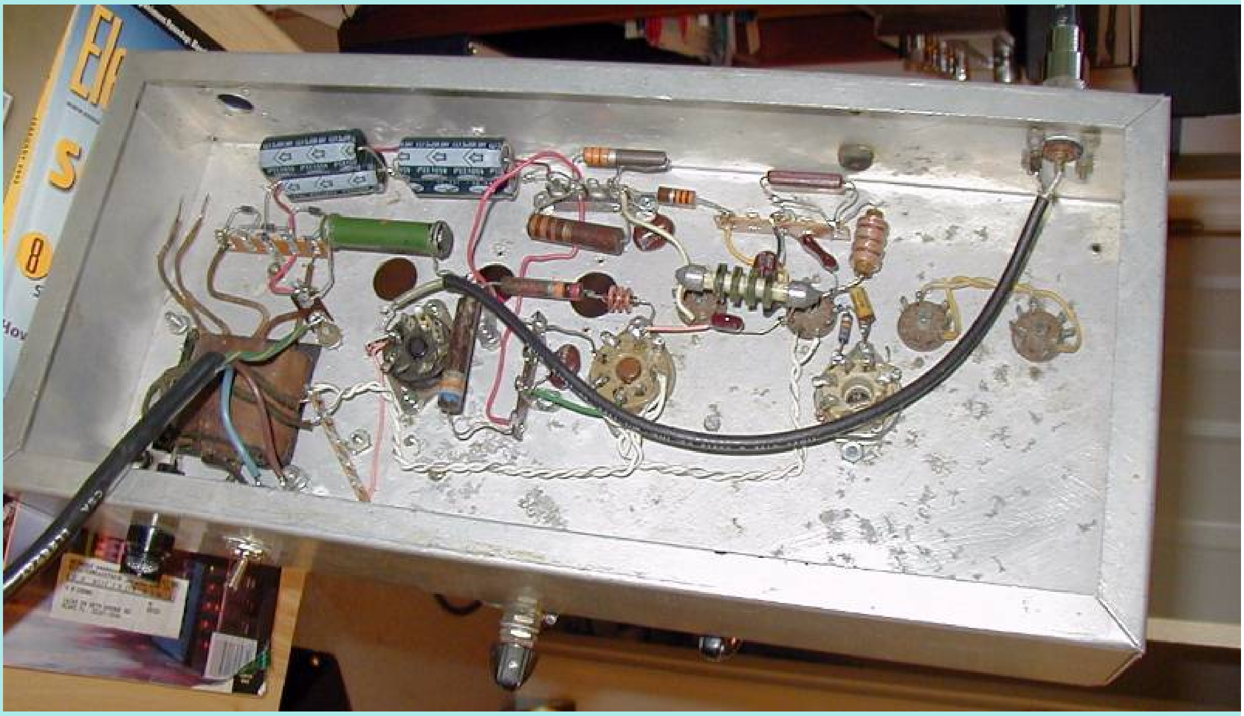
Incidentally:
Thanks to QUARTSLAB in England for some of the experimental crystals I am using.

Jan 4 2003

I plan to post the complete schematic diagram and other details about this rig on this web site.

In spite of my use of many substitute parts - the rig has lived up to my expectations and I now have RF emanating from the 6CL6 oscillator and I can tune the final.

I plugged in a 7225 kc. rock and hauled her upstairs to the shack, tuned the receiver to 7225, and lo and behold I have a strong, clean signal!



Jan 4 2003

You can see the changeover relay here - it was not wired up yet.
I have since added: 1) Front panel T-R switch to turn on the B+ (Grid block bias stays on) plus change the antenna over all in one.
2) Grid-block keying.

Jan 5, 2004

I am now ready to go for it this evening on 7029 kHz and 7049 kHz so I hope all of you other enthusiasts are going to be listening for me tonight and every night on those two frequencies. I may be on in the mornings too, so please listen around 0900 to 1300 UTC also!

How about some of you brave VK and ZL chaps taking a listen for me?

Jan 6, 2004

I am noticing a couple of intermittents here. Sigh...
The rig went into a strange mode yesterday where it would not load properly. I turned it off for a few hours and played with all of the tank area connections and coax cabling, and after that it worked fine again. The symptoms were - loss of power out; It dropped from about 25 watts down to about 5 watts out, and would not load properly. That is: increasing the loading on the output cap of the PI network would not cause any increase in plate current as would normally be expected.
It's doing much better today. I just worked Phoenix, AZ with a solid RST 579 each way!

There also appeared to be a temporary new problem when I switched to using another rock on 7032 kcs. where it will suddenly jump frequency by a couple hundred Hertz. Now it started behaving right. Oh well! When I tapped on the chassis it jumped back again, so maybe I have another loose connection or possibly even a misbehaving crystal. I will post further observations.

Meanwhile back to making contacts, hi hi!

February 2004

Here you see the 'finished' rig for now with the plate current meter added.
It's a Weston 100 mA meter with a 1 ohm shunt to read from zero to 200 mA
There is also a 0.0033 uF at 500V DC mica bypass capacitor across the meter

to keep RF energy out of it.
There is no magic to the value of 0.0033 uF. These capacitors were what I had on hand. You could just as easily use 0.01 or .002 uF caps.

SCHEMATIC OF THIS TRANSMITTER

Meter is not shown, but it is a 0-100 mA DC meter inserted in the plate circuit to monitor current. There is a 1 ohm resistor in parallel with this meter, and it also has a 0.003 uF bypass capacitor across the terminals in parallel with the shunt resistor. The true scale is now 0-200 mA so all readings are doubled.

Voltage measurements

I took these measurements because something has been intermittently changing so that the power out drops to about 20% of normal and the plate current goes high. Normal plate current under load is about 40 mA. When it is acting up, the load cap has to be at the maximum (fully meshed) setting and the plate current is still about 60 mA which is not right. Since I can't readily make the problem come and go I set up this chart to refer back to when it is acting up:

(Remember this is an older transfoermer from a 1940s-era Bogen audio amplifier! Back then the AC line voltage was usually around 110V AC, inlike today's 120 to 125V AC found in most homes.)

AC Filament voltage = 6.6V AC
High voltage secondary, no load = 772V CT
DC Voltage HT (B+), no load = 495V DC
DC Voltage HT (B+), full load = 462V DC

6CL6 plate, no load = 225V DC
6CL6 plate, full load = 216V DC

6CL6 Screen, no load = 133V DC
6CL6 Screen, full load = 127V DC

2E26 plate, no load = 495V DC
2E26 plate, full load = 462V DC

2E26 screen, no load = 490V DC
2E26 screen, full load = 136V DC

6CL6 Data Sheet in PDF format

6CL6 mini data sheet GIF

2E26 Data Sheet in GIF format

2E26 Full Data Sheet in PDF Format

Future plans include -
1) Pilot light.
2) Solid state conrol of the grid-block keying so I can use an electronic keyer if desired. **DONE**
3) VFO - or DDS VFO for full coverage.
4) Screen grid modulation with a 12AX7 and 6DE7 a-la Heathkit DX-60, Cheyenne etc.

Of course the most exciting part is just getting it on the air now and making some contacts.

On January 5th I made the first QSO on 7049 kHz CW (Using my 7050 rock) with AF4FW in North Carolina.

Congratulations, Warren, and thank you for listening
to me through the annoying Spanish SSB "Slop Bucket" QRM!

Stations contacted so far:

AF4FW = Warren in Murphy, NC
K8BHG = Lee in Bluefield, WV
K4JEJ = Luke in Jupiter, FL
W5TVW = Sandy in Hammond, LA
K5DOA = Darwin in Hockley, TX
KJ5CR = John in Bryan, TX
W8DIZ = Diz in Cincinnatti, OH
W0MFQ = Tom in St. Charles, MO
K9LIR = John in Marion, IN
K1OPQ = dave in New Hampshire
K8ORD/7 = Ken near Phoenix, AZ
K5BQ = Dale in Ponder, TX
KB8ANY/M = Paul in Cincinatti, OH
K4CA = Paul in Madison, AL
WB4RDH = Rick in Moreland, GA

OK - I think I am almost finished adding any more of
these loggings, he he!

Read AF4K's early experiences with electronics and radio

COMMENTS?

E-mail 

You are visiting the website at: *http://www.af4k.com*

The “Tree Antenna”

RCC Aug & Oct 2006 – Dave/WB7ESV

Aug 2006 Article

What is unique about this antenna is that it is only a tree. The tree is used as a Gamma or Shunt fed vertical. To make this work, we drove a 3 ½” deck screw into the tree (you need to make contact with the sap vein), at about 15’ above the ground (15’ to 20’ will work). We attached a wire to the screw, extended the wire 2’ perpendicular to the tree, tied a rope to the wire at the 2’ point, tied the other end of the rope to a tree limb and dropped the wire to the ground.

At the ground we drove a 3’ ground rod 2 feet out from the base of the tree and attached a rope to the ground rod and to the wire to keep the wire tight.

At the feed-point end of the wire we connected an MFJ-901B tuner strapped for “WIRE” operation and connected the tuner ground to the ground rod.

Coax was connected and run to the operating position in a tent. To tune the antenna, an MFJ-269 SWR Analyzer was connected to the tuner input and the tuner adjusted for minimum SWR at the center of the operating band. The antenna is capable of operation on 10 - 80 meters. Many contacts were made including: Hawaii, Texas, Oklahoma, Montana, Wyoming, Utah, Idaho, California, VE6 and VE7.

The tree height should be no shorter than 30 feet and any wire antenna tuner will work.

Oct 2006 Article

Those who are building or have built it are: Jeff, KB6IBB, in The Dalles, OR; Tom, KD7ZOS, in Portland, OR; Dave, W0OXB, in Stillwater,MN; and Larry, KE7HGC, in Vancouver, WA.

Those who have it up and running have made contacts all over the U.S. and have stated that: .If I can hear them, I can talk to them.

If you are in an area that frowns on antennas and you have a tree that is at least 30. tall, give it a try. What you will need to build the Tree Antenna is: A tree that is at least 30’ tall, a 3# nail or wood screw, (not galvanized), 20’- # 12 - # 16 AWG copper wire (can be solid or stranded, un-insulated or insulated), a 4’ ground rod, wire clamp for the ground rod, 2-egg insulators and an antenna tuner that can be remotely adjusted, (ICOM AH-4, SGC SmartTuner, Home Brew with small motors to operate the variable capacitor(s) and inductor, etc). If you decide to ‘Home Brew’ a tuner, there are several in the ARRL Amateur Radio Handbook that will work very well.

Solder one end of the copper wire to the nail/screw. At about 15’- 18’ up the side of the tree drive the nail/ screw into the tree so as to penetrate the sap vein of the tree. (This is important for RF conduction.) Draw the wire out 2’ perpendicular from where you drove the nail/screw and support the wire with an egg insulator tied to a rope which is tied off to a limb of the tree and let the rest of the wire drop down to the ground.

Drive the ground rod into the ground 2’ out from the base of the tree leaving about 3’ of the rod above ground level. Attach a short piece of rope to a egg insulator and attach the other end of the insulator to the copper wire so that the insulator/wire is about 6’ above the top of the ground rod. Leave enough wire to connect to the tuner.

Attach a short piece of rope to a egg insulator and attach the other end of the insulator to the copper wire so that the insulator/wire is about 6’ above the top of the ground rod. Leave enough wire to connect to the tuner.

Attach the rope to the ground rod and install the antenna tuner to the end of the wire and place the tuner in a plastic container to protect it from the weather.

Connect a short ground wire from the ground side of the tuner to the ground rod with a clamp and make sure all connections are tight and sealed from weather.

If you are wondering where the “Tree Antenna” Comes from, it’s from a WWI/WWII Army Signal Corps Emergency Communications Manual.

Regine / April 7, 2014 / bio, bioart, DIY, green, sound

Tree Antenna: using trees for radio transmission

BioArt Laboratories, Tree Antenna at Age of Wonder (demo outside Baltan Laboratories). Photo by Sas Schilten

BioArt Laboratories, Tree Antenna at Age of Wonder (demo outside Baltan Laboratories). Photo by Sas Schilten

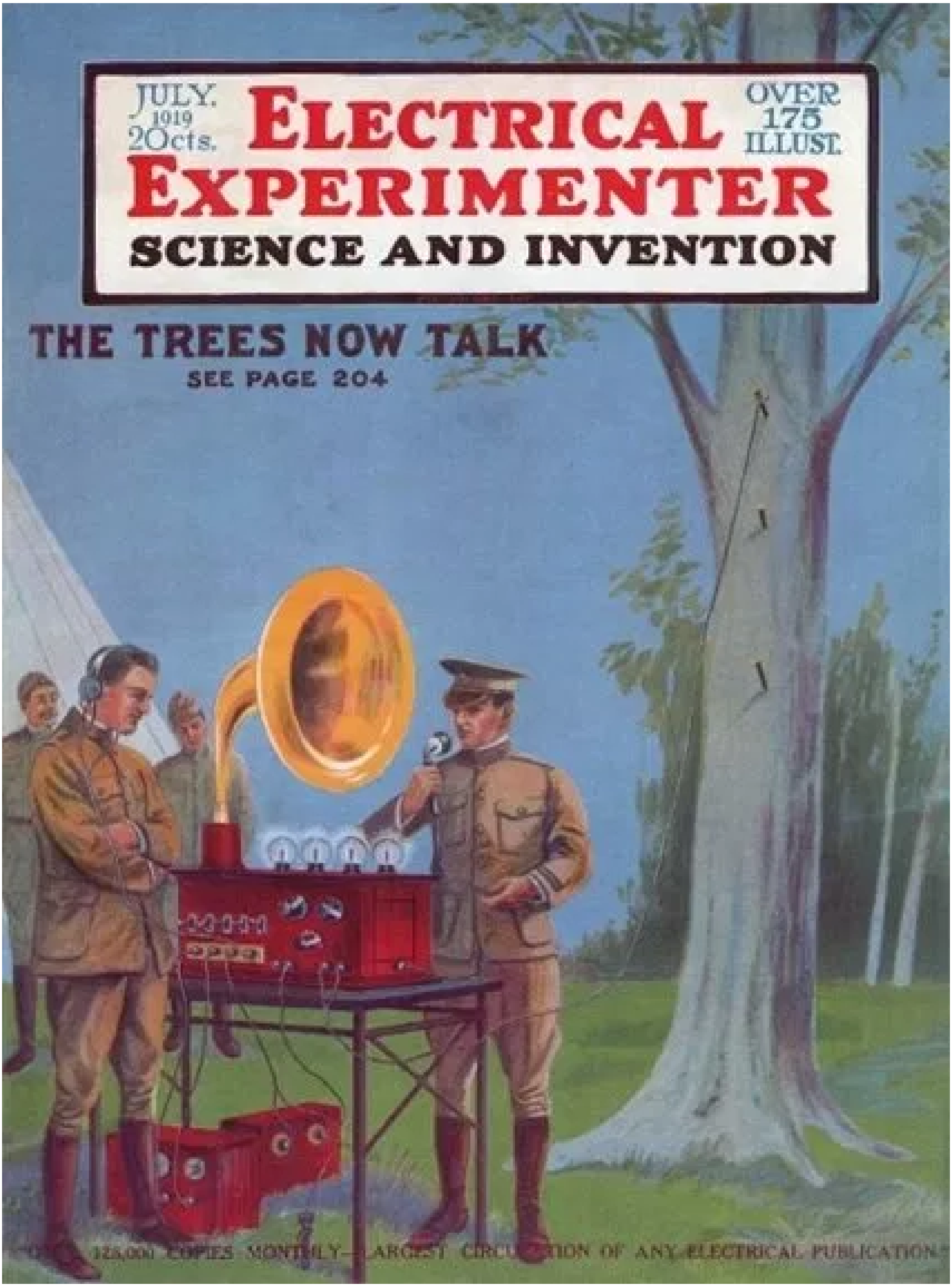
I already mentioned the festival Age of Wonder last week in my notes from Nick Bostrom's talk about (human and artificial) Super Intelligence. The festival attempted to reflect on the challenging but ultimately exciting techno-mediated times we are living with a series of performances, keynotes and art installations. BioArt Laboratories illustrated the essence of the festival with Tree Antenna, an installation and workshop that engaged with alternative wireless communication, ecology, DIY culture and historical knowledge.

The Eindhoven-based multidisciplinary art&design group recreated an early 20th Century experiment in which live trees are used as antennas for radio communication.

General George Owen Squier, the Chief Signal Officer at the U.S. army not only coined the word "muzak", in 1904 he also invented in 1904 a system that used living vegetable organisms such as trees to make radio contact across the Atlantic. The invention never really took off as the advent of more sophisticated means of communication made tree communication quickly look anachronistic.

Tree communication was briefly back in favour during the Vietnam War when U.S. troupes found themselves in the jungle and in need of a reliable and easy to transport system of

communication but after that, only a few groups of hobbyists used tree antennas for wireless communication.


JULY. 1919 20cts.
ELECTRICAL EXPERIMENTER
OVER 175 ILLUST.
SCIENCE AND INVENTION
THE TREES NOW TALK
SEE PAGE 204

George O. Squier ~ Trees as Antennas (Scientific American, June 14, 1919 & British Patent Specification # 149,917)

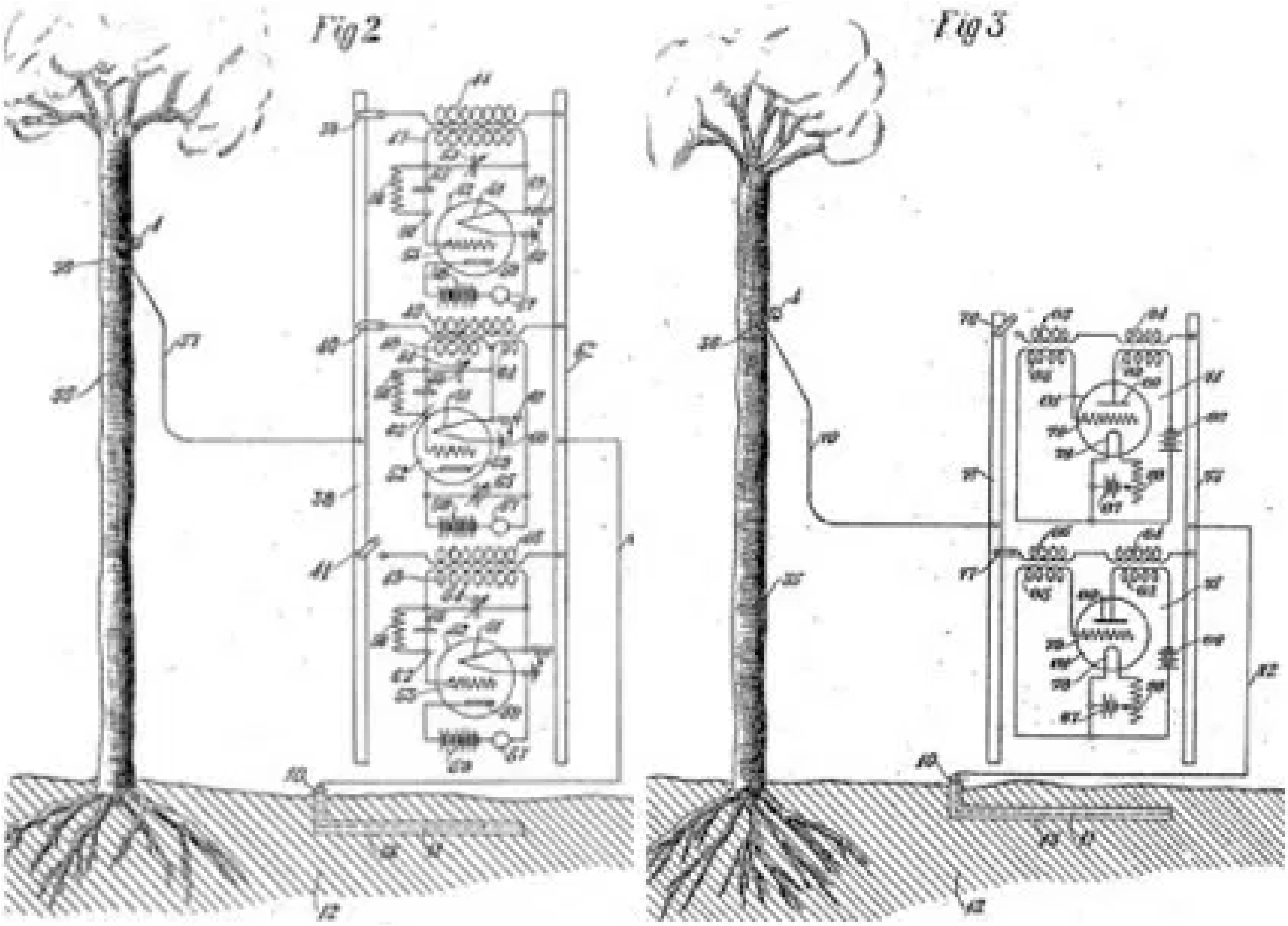


Illustration from Squier's patent

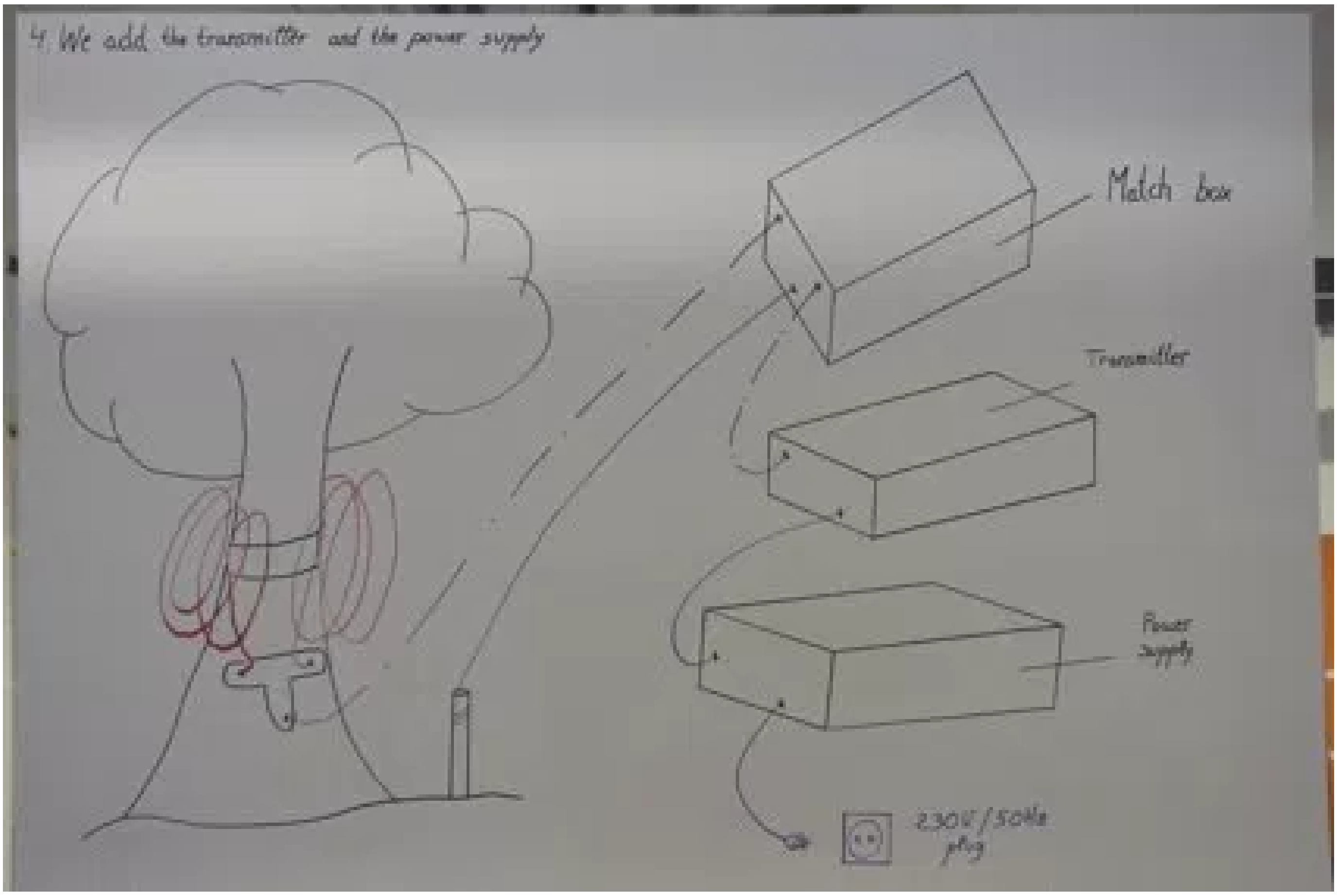
During the last afternoon of Age of Wonder, BioArt Laboratories invited members of the public of all ages and background to join them and bring back tree antennas to our attention. Participants of the workshop could craft simple and affordable devices that would allow anyone to use the tree in their backyard as a radio receiver (it is also possible to broadcast from your tree but the technology is slightly more expensive and it requires permits.)

Squier drove a nail into the tree, hung a wire, and connected it to the receiver. The BioArt Laboratory team used flexible metal spring that wrapped around the trunk as planting a nail into the tree would have damaged it. Their system definitely works as the team managed to communicate with amateurs radios from countries as distant as Italy and Ukraine.

Right now there are only a few amateurs using tree and other high plants for wireless communication but the BioArt Laboratory's objective is to spread the word about this simple and affordable technology and gradually build up a world-wide forest of antennas.

BioArt Laboratories, Tree Antenna at Age of Wonder (workshop at Baltan Laboratories.) Photo by Sas Schilten

BioArt Laboratories, Tree Antenna at Age of Wonder (workshop at Baltan Laboratories.) Photo by Sas Schilten



BioArt Laboratories, Tree Antenna at Age of Wonder (workshop at Baltan Laboratories.) Photo by Sas Schilten

Obviously, in this experiment the tree is part and parcel of the functionality of the antenna. We're thus not speaking of questionable antennas disguised as tree.

BioArt Laboratories, Tree Antenna at Age of Wonder (demo outside Baltan Laboratories). Photo by Sas Schilten

BioArt Laboratories, Tree Antenna at Age of Wonder (demo outside Baltan Laboratories). Photo by Sas Schilten

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BioArt Laboratories, Tree Antenna at Age of Wonder (demo outside Baltan Laboratories). Photo by Sas Schilten

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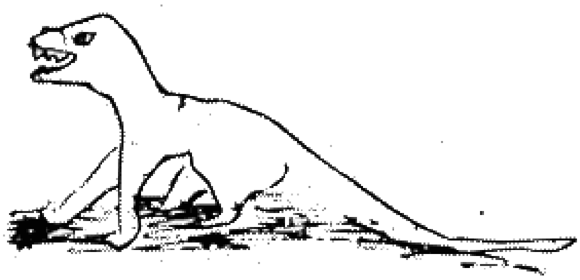

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George SQUIER

Tree Antennas

General George O. Squier

***Scientific American* (July 14, 1919, p. 624) ~**

"With Trees For Ears"

A Wireless Station Within the Reach of Everybody

With a pair of receives to his ears, an amazed visitor to a certain radio station heard a high-toned hum which changed to a low growl, then skied to the upper reaches of the musical scale in a

faint, very faint buzz, as if some microscopic mosquito had had his song made audible. The operator rapidly rapidly turning the knobs on his couplers and condensers, raised his hand: suddenly, through the changing radio signals which were clamoring for attention together in the receivers came his voice; "There --- the loud, easily heard one is New Brunswick; the fainter, lower one is Nauen, in Germany".

If all this had taken place in the great Arlington station one would not have wondered, save perhaps at the inability to tune out all radio but Nauen. But it was a little portable house erected in thick woods near the edge of the District of Columbia and the signals were received through an oak tree for an antenna.

It is not a joke nor a scientific curiosity, this strange discovery of Gen. George O. Squire, Chief Signal Officer, that trees --- all trees, of all kinds and all heights, growing anywhere --- are nature's own wireless towers and antenna combined. The matter first came to his attention in 1904, through the use of trees as grounds for Army buzzer and telegraph and telephone sets, which, in perfectly dry ground and in a dry season, functioned poorly or not at all with ordinary grounds. Right then he began experiments with a view to seeing what possibilities, if any, the tree had as an aerial. But in 1904 radiotelegraphy was far more undeveloped than at present, and vacuum amplifying tubes were not thought of.

During the war the Signal Corps established a chain of special receiving stations in different localities to copy and record enemy and allied radio messages. Some of those stations were instructed to test the efficiency of growing trees as receiving antennae.

With the remarkably sensitive amplifiers now available, it was not only possible to receive signals from all the principle European stations through a tree, but it has developed beyond a theory and to a fact that a tree is as good as any man-made aerial, regardless of the size or extent of the latter, and better in the respect that it brings to the operator's ears far less static interference.

This is a rather broad statement, yet there beyond the Capital of the nation stands a little portable house, the oak tree, a small receiving set and a couple of enlisted men and an officer on duty; and the curious may, with permission, hear for themselves that the signals so received are neither faint not interrupted, but strong, full-toned dots and sashes even when they come from far-off Nauen. Page after page is copied daily from the propaganda material which Nauen sends out by the ream. Lyons, Poldhu, ships at sea, even the NC-4 on her way, are heard plainly. As for New Brunswick or nearby Arlington --- they deafen the listener if he is unwise enough to try to "take" them otherwise than with the phones lying on the tables.

It will puzzle the amateur as it has puzzled the experts, how a tree, which is certainly well grounded, can also be an insulated aerial. The method of getting the disturbances in potential from treetop to instrument is so simple as to be almost laughable. One climbs a tree to two-thirds of its height, drives a nail a couple of inches into the tree, hangs a wire therefrom, and attaches the wire to the receiving apparatus as if it were a regular lead-in from a lofty copper or aluminum aerial. Apparently some of the etheric disturbances passing from treetop to ground through the tree are diverted through the wire --- and the thermionic tube most efficiently does the rest.

It is interesting to learn that the tree behaves very much like any other aerial; it receives better in dry clear weather than in muggy, damp weather. It plucks messages from the ether more clearly at night than in the day. It is affected very little by rain. It is affected not at all by the presence of other trees; so far as has yet been ascertained it makes little difference whether one drives his nail in a tree in the forest or a lone tree on the plain. Certainly it makes no difference that amounts to anything whether the tree be just an ordinary tree or a giant; it was a 60-foot oak over which the very awe-struck correspondent heard Nauen telling a waiting world what good people the Germans really are. And to prove that it made no particular difference what kind of tree was used the officer in charge switched to a pine tree, which received equally well.

A dead tree will not do, and a tree not in leaf is not so sensitive as one in full foliage. It makes much difference where the nail is driven. General Squier calls the proper place the optimum point, and experimentally it has been determined that two-thirds of the distance from ground to top is the best place -- in a 60-foot tree, 40 feet from the ground.

One nail is sufficient, and it may be any kind of nail; but copper is preferred as not rusting. In practice, if a tree station is to be at all permanent, several nails would be driven and connected to the same wire, each additional nail up to 6 or 8 making the diverted current a little stronger. But 40 nails apparently produce no clearer signals than half a dozen.

The tree may serve as a receiving station for several sets, either connected in series with the same material or from separate terminals.

Some skeptics have expressed the belief that it was not the tree, but the wire leading to the nail in the tree which was the real aerial. The absurdity of thinking a 40-foot wire could receive the widely differing wave lengths which come through the tree station is obvious, but to set any doubt at rest, the wire to the tree has been hung to the nail by means of an insulator, when the signals immediately cease, only to come in as strong as ever just as soon as the connection is again established.

Just what will the tree do as a transmitting station for radio telegraphic messages has not been determined in the Signal Corps Experimental Laboratory. As those in charge express it, "The fact has been demonstrated, but the matter is still in laboratory stage only. What remains to be done now is to develop the best methods of using the demonstrated fact".

But it has already been shown that the tree can be used in wireless telephony and for short distances it has been shown that two-way telephonic communications is easily established through trees with remarkably low values of transmitting antenna current.

If a tree may be used to send wireless telephonic waves it seems not unreasonable to suppose that it will do so as easily with the telegraphic waves. At present the Signal Corps is at work on apparatus to test the possibilities of the tree as a transmitting station.

Just what this development of the art of radio telegraphy may mean has not yet been worked out. It is the history of most discoveries that their potentialities are hardly dreamed of when they are first made --- for instance the telephone, the electromagnet, the vacuum tube amplifier. But it seems fairly obvious that in war, at least, the tree receiving station opens up great possibilities.

True enough there are few trees which remain intact under shell fire, and doubtless with this possibility in mind the armies of the future (if there be such) will in action consider all trees as dangerous enemy aerial stations. But there will always be trees behind the lines and not all actions will be fought on bare ground. What would it have meant to the "lost battalion" to have had a tree wireless set along by which it could have heard that every effort was being made to find and relieve it, or by which it might have sent back messages supplementing that carried by the pigeon?

The greatest development, however, of the tree as the foundation for a receiving and possibly a sending station will come in peace uses. General Squier has written:

"In view of what has been accomplished in space telegraphy, it is difficult to predict to what extent this means of communication may ultimately be developed. If, as indicated in these experiments, the earth's surface is already generously provided with efficient antennae, which we have but to utilize for such communication, even over short distances, it is a fascinating thought to dwell upon in connection with the future development of the transmission of intelligence.

"Since a transmitting station is a central point for electromagnetc waves sent out in all directions over the surface of the earth, a large class of information, such as meteorological reports, crop reports, and general news items of interest to all, may in time be sent from central points, to be received in many places within the radius of influence of the signal station, and this, too, by the simplest form of apparatus."

The amateur wireless world will unquestionably take an intense interest in the tree radio work. At present, while the government has lifted the ban upon amateur aerials, it has not removed the structures against sending.

The aerial is always the greatest problem for the amateur. Lack of both money and material prevents him from erecting anything very large or of very great capacity. If any lad with a receiving set and some thermionic tubes can hook to a tree and take in any wavelength he can tune to, will not tree radio vastly increase the devotees of this particular variety of indoor sport? The matter is one of some importance, inasmuch as many valuable recruits to the radio world have come from amateur ranks, and many a radio engineer had got his first taste for the fascinating art through a homemade tuning coil and detector, under the attic roof. The greater the amateur wireless world, the quicker the development of the art as a whole.

Explorers, discoverers, engineers in far places, the forest service, the woodsman, all have use for the new development. Moreover the tree as an antenna offers unusual possibilities for the investigation of atmospheric phenomena and for what may be called the physics of botany (or the botany of physics) and perhaps is the road by which the unsolved puzzle of growth may be studied.

Meanwhile, it is a thought not without great power to move the sensitive imagination that every tree, growing everywhere, is a wireless tower and antenna and that, as General Squier says, "It is significant that a tree, possessing utility and natural strength, architectural beauty of design and endurance far superior to artificial structures prepared by man, should be able yet further to minister to his needs".

***Electrical Experimenter* (July 1919), p. 204**

Talking Through The Trees

by

Major-General George O. Squier

(Chief Signal Officer, US Army)

How Transatlantic Radio messages Are Copied Via Tree Antenna

As long ago as 1904, the author conducted some experiments with a view to utilizing growing trees as antennae for radio-telegraphy and discovered the efficacy, in a general way, of using a direct metallic contact to certain trees (principally Eucalyptus) to increase the audibility of radio signals. My attention was first called to this phenomenon during the course of summer maneuvers of the Army at Camp Atascadero, CA, where, due to the prevalence of the dry season of the soil, it was found that the regular Army buzzer telephone and telegraph sets were inoperative with any ordinary ground or earth but became operative when connected to a metallic nail driven in the trunk or roots of a live tree. This incident led the author to pursue the subject experimentally in the autumn of 1904 continuing the experiments to the range of frequencies than employed in radio-telegraphy.

Tree Antennae

In connection with the organization and development of Transatlantic radio reception, which was carried out during the period of the war to provide against the possibility of the interruption of the submarine cable system, the Signal Corps established a chain of special receiving stations in different parts of the United States to copy and record enemy and Allied radio messages from European stations for the information of our Army General Staff.

In the prosecution of this work, directions were given to the Signal Corps Laboratory at Camp Alfred Vail, Little Silver, NJ, and also to the experimental staff in Washington to test the efficiency of growing trees as receiving antenna, in connection with this service, using the vastly superior technique and facilities now represented in the radio Art as compared with the crude apparatus with which the discovery was made in 1904. With a collection of apparatus representing the most advanced state of the radio Art, the problem, as a war measure, was attacked anew and has now reached a point where a very brief outline of some of the

physical results obtained should be presented in the interests of the development of the Art in general. Since the phenomena involved embrace a variety of physical problems rather than strictly engineering ones, these data are presented in the hope that our scientists may see in the experiments some points of departure for further research.

It was immediately discovered that with the sensitive amplifiers now in use it was possible to receive signals from the principal European stations by simply laying a small wire netting on the ground beneath the tree and connecting an insulated wire to a nail driven in the tree well within the outline of the tree top. See Figure 1. Messages having been received from England, France, Germany and Italy.

This encouraging first result justified a more careful examination of the phenomena and the most suitable arrangement of circuits for the purpose.

And Now For the Floraphone

The messages carried over this tree telephone and telegram system have been named by the writer. They are to be ‘floragrams’. The tree telephone is to be a ‘floraphone’; the tree telegraph a ‘floragraph’.

The discovery is now announced after experiments covering 15 years, beginning in California and continuing intermittently until the outbreak of the war, when they went forward with vigor as an emergency means of communication. The system was utilized during the war in listening-in on the German radio communication.

The final development took place in a small portable laboratory, purchased from a mail order house, capable of being carried to any place in the woods. A group of soldiers, taking turns at copying messages, assisted the writer in the development of the apparatus.

Without entering into the details of these preliminary experiments here it may be said that one fo the best receiving arrangements is found to be an elevated tree earth-terminal in the upper part of the tree top, and an earth consisting practically of several short pieces of insulated wire, sealed at the outer end, radiating out from a common center, and buried a few inches beneath the surface of the ground in the neighborhood of the tree. See Figure 2.

It was soon found that a tree-antenna could be used efficiently as a multiple radio receiving set over widely different wavelengths, see Figure 3A, receiving either from separate terminals at the same (shown dotted in Figure 3A) or different heights of the tree, or in series from the same terminal. See Figure 3B.

This same type of circuit was employed in an inverse manner for radio-telephonic transmitting purposes, although the experiments thus far have been limited to short distances. It was found that 2-way radio-telephonic communication was easily established with remarkably low values of transmitting antenna current. See diagram of this test illustrated at Figure 4.

The flexibility of this arrangement is very striking. The linking up of wire and wireless methods was found to be both convenient and efficient. Radio-telephonic messages from airplanes were readily received by the tree-antenna arrangement and transferred thence to the wire system of the city of Washington and finally received at any point desired.

Furthermore, radio-telephonic transmission through the tree-antenna was received by another tree-antenna, and automatically returned to the sender on a wire system, thus making a complete circuit. Illustrated at Figure 6.

Long distance reception on any wave length from all the larger European stations and from our ships at sea was easily accomplished and traffic copied on a 24 hour schedule by the regular enlisted operators of the Signal Corps. A small portable house serving as a field laboratory was erected in the midst of the forest area on Grant Road, Washington DC, and here was assembled a collection of amplifiers from the Army, navy, the British and French, and American manufacturers. With these facilities it was a matter of a few days to test out, at least in a superficial manner, a large number of proposed arrangements using trees as antenna.

Figure 7 shows how a number of trees can be connected up to give the effect of one large antenna.

In France officers of the Signal Corps, by the simple device of driving a spike into a tree-trunk to which connect the audion set which wireless operators use to make up wireless messages, it was found possible to listen in on communications between German airplanes and the German lines. Messages were thus intercepted in spots into which it would have been impossible to transport a field wireless apparatus. See Figure 8.

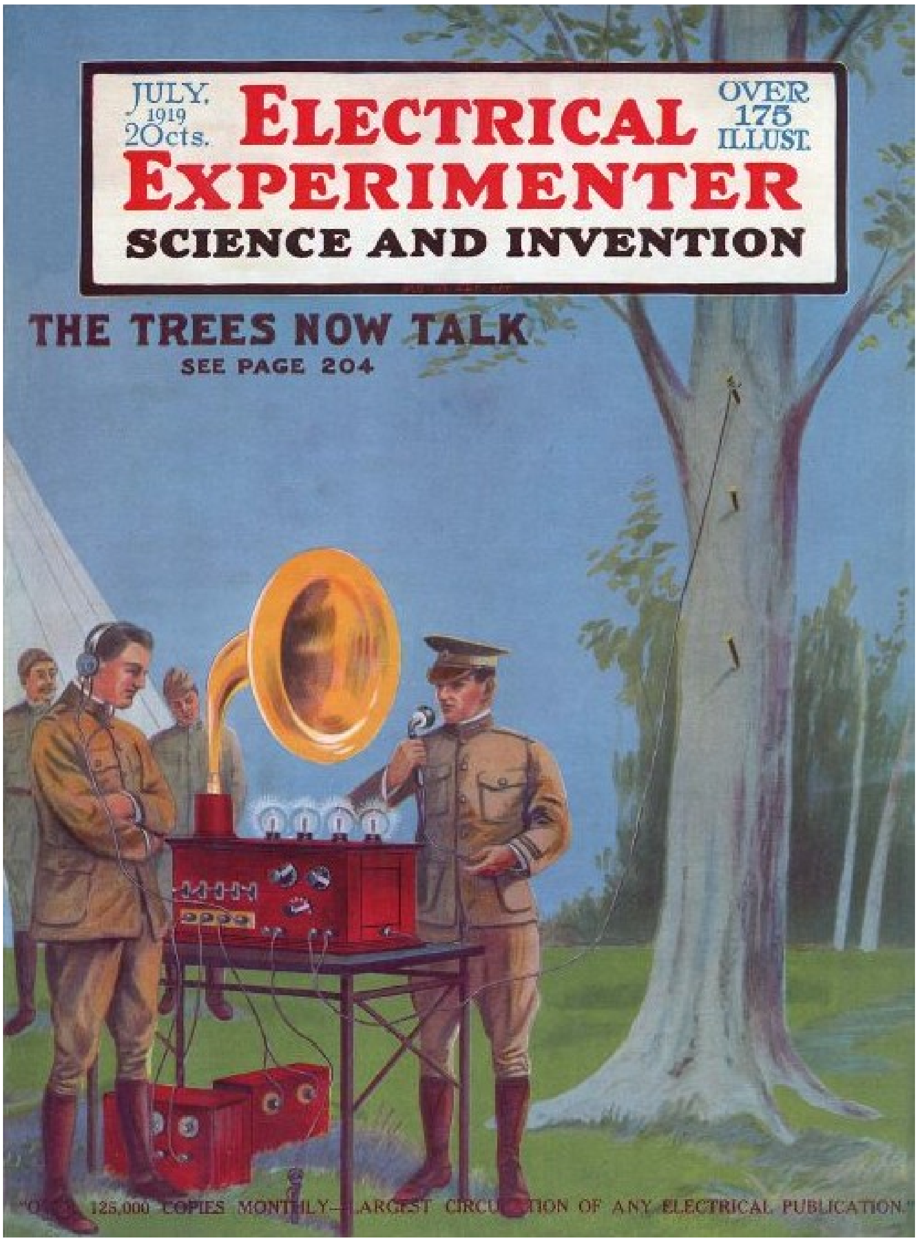
The Physics of Tree Wireless

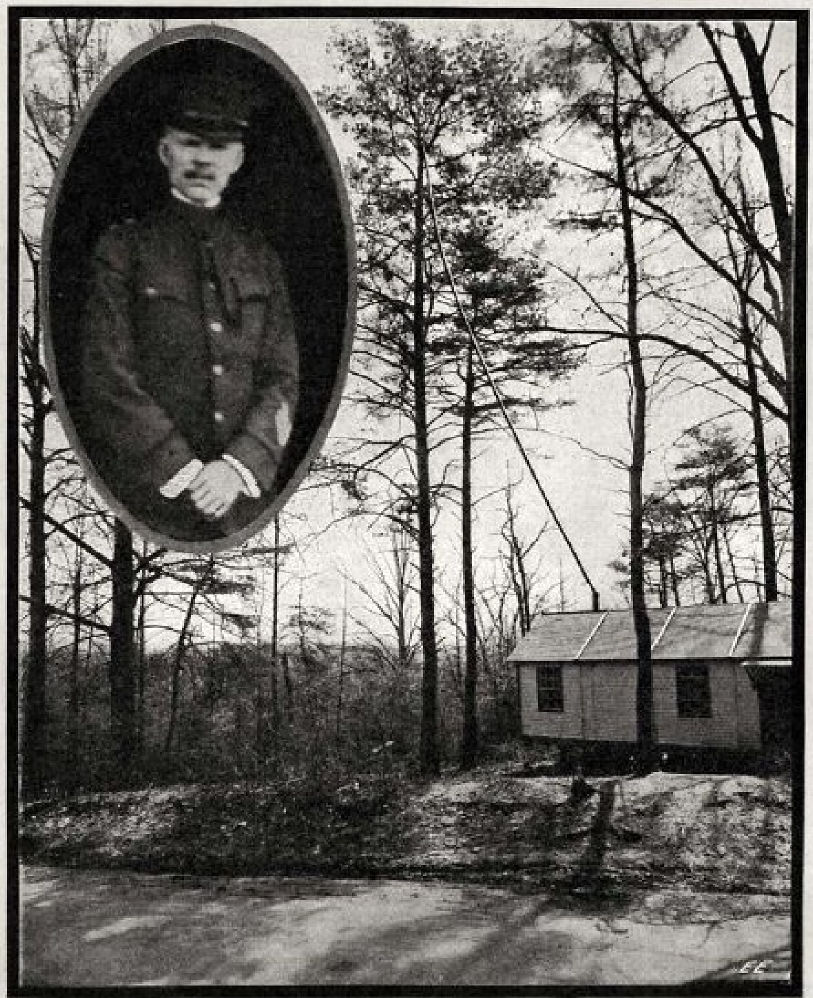
We may regard the metallic electrode rigidly driven into the living organism of a tree, as described above, as a potential earth-terminal for the study of the potential distribution on the surface of the earth itself. It has been shown in these experiments that this metallic terminal intimately connected to the earth itself and a part thereof is subject to changes of potential representing the innumerable frequencies required by modern radio-telephony and telegraphy, as well as any other electrical disturbances which may occur on the surface of the earth or the atmosphere above the earth.

It has also been shown, as expected, that we can select from this composite one or more of the different frequencies by tuned electrical loop circuits suitably connected to this electrode and study each in turn, at will, just as color screens can select a particular component of white light. We may, indeed, by means of a highly insulated conductor bring this terminal directly to the laboratory and connect it immediately to the modern thermionic tube and amplify almost at will the particular effects we are studying…

We can consider that trees have been pieces of electrical apparatus from their beginning and with their manifold chains of living cells are absorbers, conductors and radiators of the long electromagnetic waves as used in the radio Art.

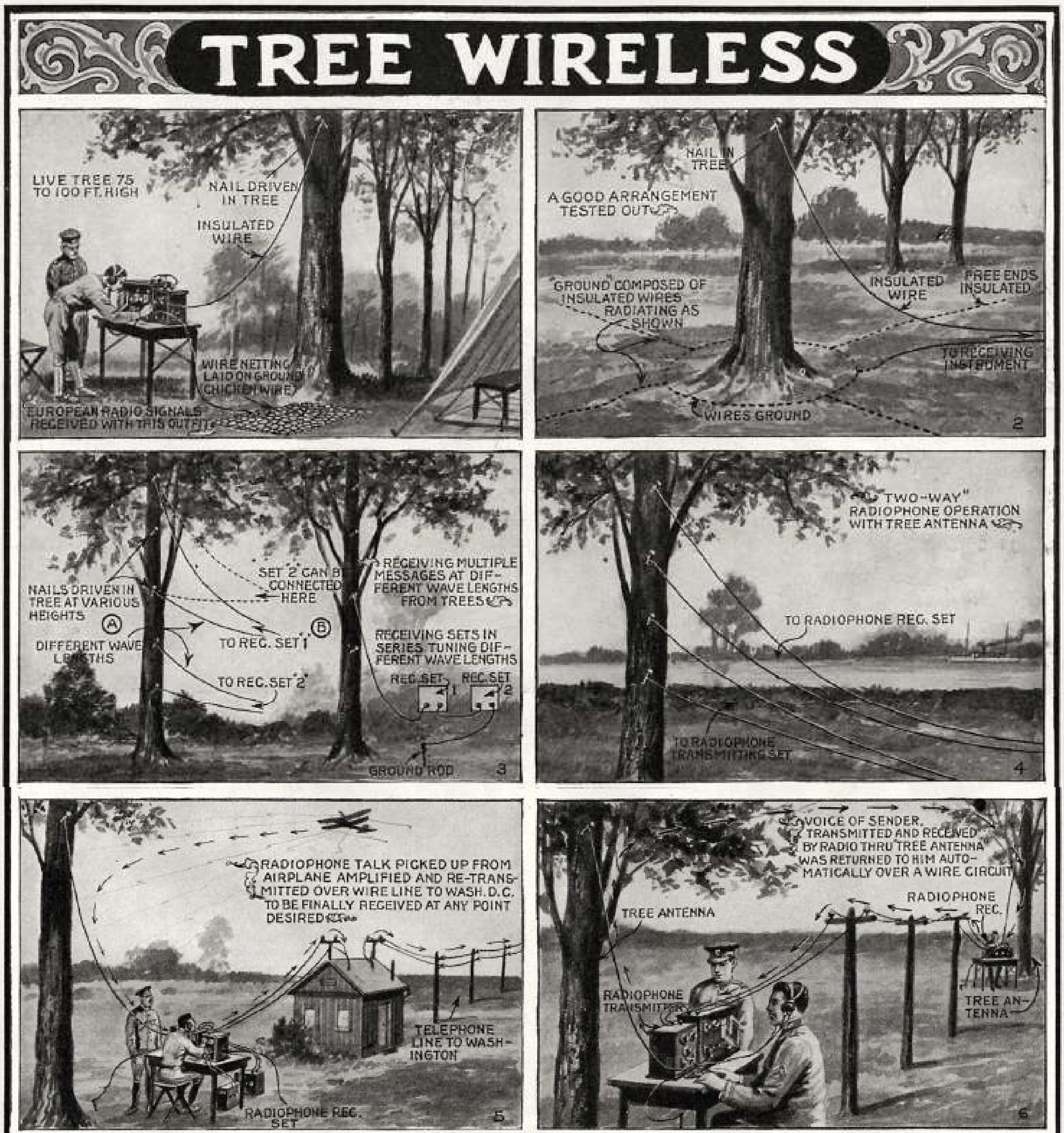
For our present purpose we may consider, therefore, a growing tree as a higly organized piece of living earth, to be used in the same manner as we now use the earth as a universal conductor for telephony and telegraphy and other electrical purposes…


JULY, 1919 20cts.
ELECTRICAL EXPERIMENTER
OVER 175 ILLUST.
SCIENCE AND INVENTION
THE TREES NOW TALK
SEE PAGE 204
125,000 COPIES
OF ANY ELECTRICAL PUBLICATION."



Signal Corps Photo

The U. S. Signal Corps Laboratory Near Washington, D. C., Where Remarkable Results Were Obtained Using Living Trees as Radio Antennae. Signals from Europe and Other Countries Were Easily Copied. Trees Have Been Successfully Used Also for Radiophone Transmission. Insert View: Major General George O. Squier, Inventor of "Tree Wireless."


TREE WIRELESS
LIVE TREE 75 TO 100 FT. HIGH
NAIL DRIVEN IN TREE
INSULATED WIRE
WIRE NETTING LAID ON GROUND (CHICKEN WIRE)
EUROPEAN RADIO SIGNALS RECEIVED WITH THIS OUTFIT
NAIL IN TREE
A GOOD ARRANGEMENT TESTED OUT
GROUND COMPOSED OF INSULATED WIRES RADIATING AS SHOWN
INSULATED WIRE
FREE ENDS INSULATED
TO RECEIVING INSTRUMENT
WIRES GROUND
2
NAILS DRIVEN IN TREE AT VARIOUS HEIGHTS
A
B
SET 2 CAN BE CONNECTED HERE
DIFFERENT WAVE LENGTHS
TO REC. SET 1
TO REC. SET 2
RECEIVING MULTIPLE MESSAGES AT DIFFERENT WAVE LENGTHS FROM TREES
RECEIVING SETS IN SERIES TUNING DIFFERENT WAVE LENGTHS
REC. SET 1
REC. SET 2
GROUND ROD
3
"TWO-WAY" RADIOPHONE OPERATION WITH TREE ANTENNA
TO RADIOPHONE REC. SET
TO RADIOPHONE TRANSMITTING SET
4
RADIOPHONE TALK PICKED UP FROM AIRPLANE AMPLIFIED AND RE-TRANSMITTED OVER WIRE LINE TO WASH. D.C. TO BE FINALLY RECEIVED AT ANY POINT DESIRED
TELEPHONE LINE TO WASHINGTON
RADIOPHONE REC. SET
5
VOICE OF SENDER, TRANSMITTED AND RECEIVED BY RADIO THRU TREE ANTENNA WAS RETURNED TO HIM AUTOMATICALLY OVER A WIRE CIRCUIT
TREE ANTENNA
RADIOPHONE REC.
RADIOPHONE TRANSMITTER
TREE ANTENNA
6

British Patent Specification # 149,917

Improvements in & Relating to Radio Communication Systems

George O. Squier

This invention relates to radio communication systems. More particularly, the invention relates to radio transmission and reception through the use of living vegetable organisms such as trees, plants, and the like.

As disclosed in the Specification of my prior Letters Patent No. 25,610 (1904), I have discovered heretofore that tall trees and like growing vegetation possessed electrical conductivity of a certain nature adapted for the reception of signaling electromagnetic waves and capable of forming a part of an antenna or serial with the use of a direct earth "ground" or equivalent point of connection with the tree, in the potential node region.

I have recently discovered that living vegetable organisms generally are adapted for transmission and reception of radio or high frequency oscillations, whether damped or undamped, with the use of a suitable counterpoise. I have further discovered that such living organisms are adapted for respectively transmitting or receiving a plurality of separate trains of radio or high frequency oscillations simultaneously, in the communication of either or both telephonic or telegraphic messages.

In such use of an antenna comprising living vegetable organism and a counterpoise, I have discovered that optimum results are obtained upon arranging the point of connection of the transmitting or the receiving set within a certain range of the tree, or other living vegetable organism; for trees indigenous in the temperate zones, I have discovered that such optimum point of connection is in a region approximately two-thirds of the height of the tree above the exposed surface of the earth.

In accordance with my invention for receiving radio trains of telephonic or telegraphic high frequency oscillations, a plurality of receiving sets attuned respectively to any desired frequency, may be connected by the same leading-in wire to the same tree, whereby such tree serves as the common receiving antenna for the respective individual receiving sets; and, similarly, for transmitting radio trains of telephonic or telegraphic high frequency oscillations, a plurality of transmitting sets respectively resonant to any desired frequency may be connected by a common lead-in wire to the same tree serving as the common antenna.

In the more preferred forms of my invention, I have devised suitable means for selective directional reception of radio oscillations of any desired definite frequency, by the use of a coil having the turns of its windings disposed in substantial parallelism and mounted to be rotated in a horizontal plane, whereby the received oscillations are restricted to the direction coincident with or parallel to a plane lying normal to any plane passing through any turn of the windings of the coil.

The counterpoise comprises preferably a suitable extent of conductor in the form of one or more lengths of wire disposed below the surface of the earth and suitable insulated therefrom; it is desirable to arrange a number of individual counterpoises, each extending rectilinearly in different directions to one another and to employ in directional selection the particular counterpoise extending substantially in the selected direction.

Further features and objects of the invention will be more fully understood from the following description and the accompanying drawings, in which:

Figure 1 is a diagrammatic vertical elevation of a preferred form of the invention;

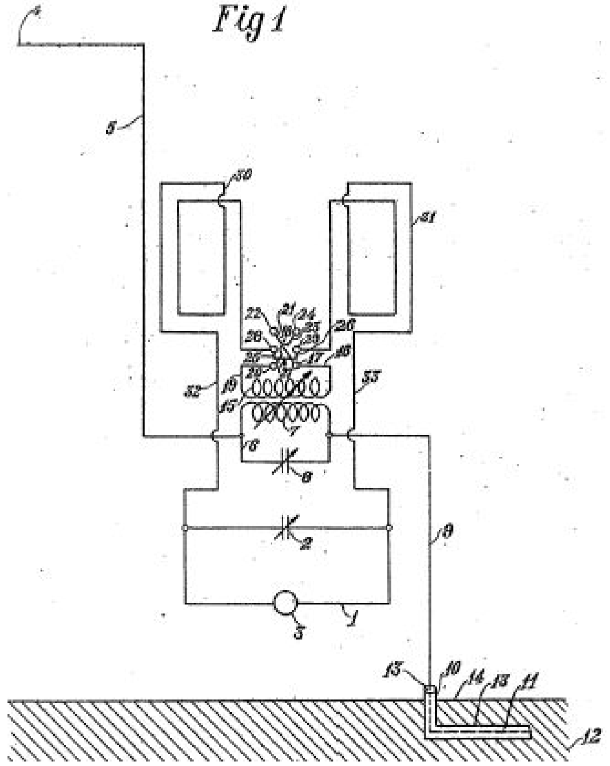


Figure 2 is a diagrammatic view of one preferred form of an arrangement of receiving sets, embodying my invention; and

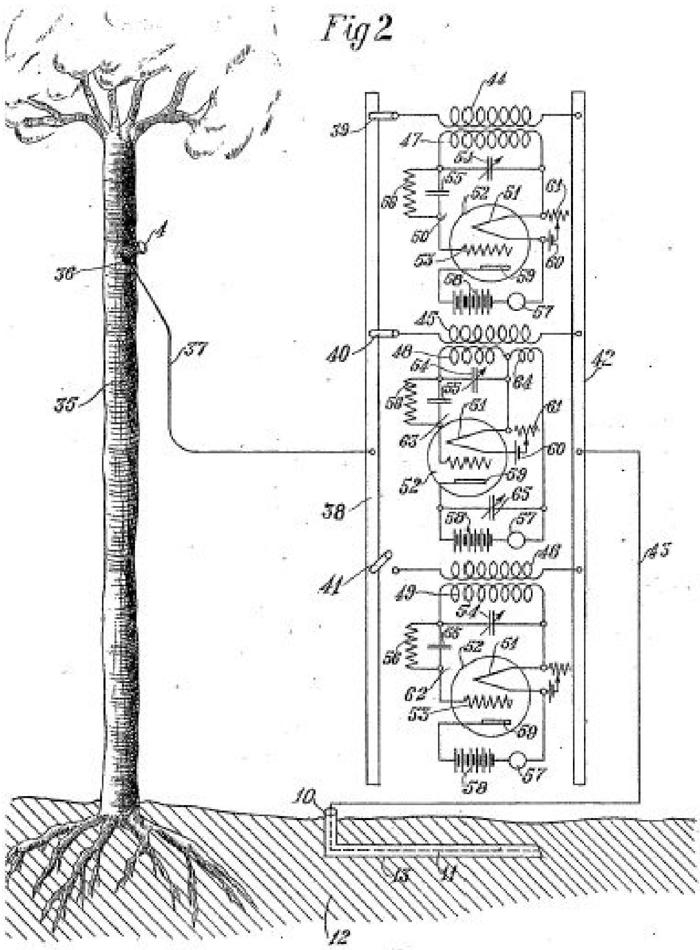
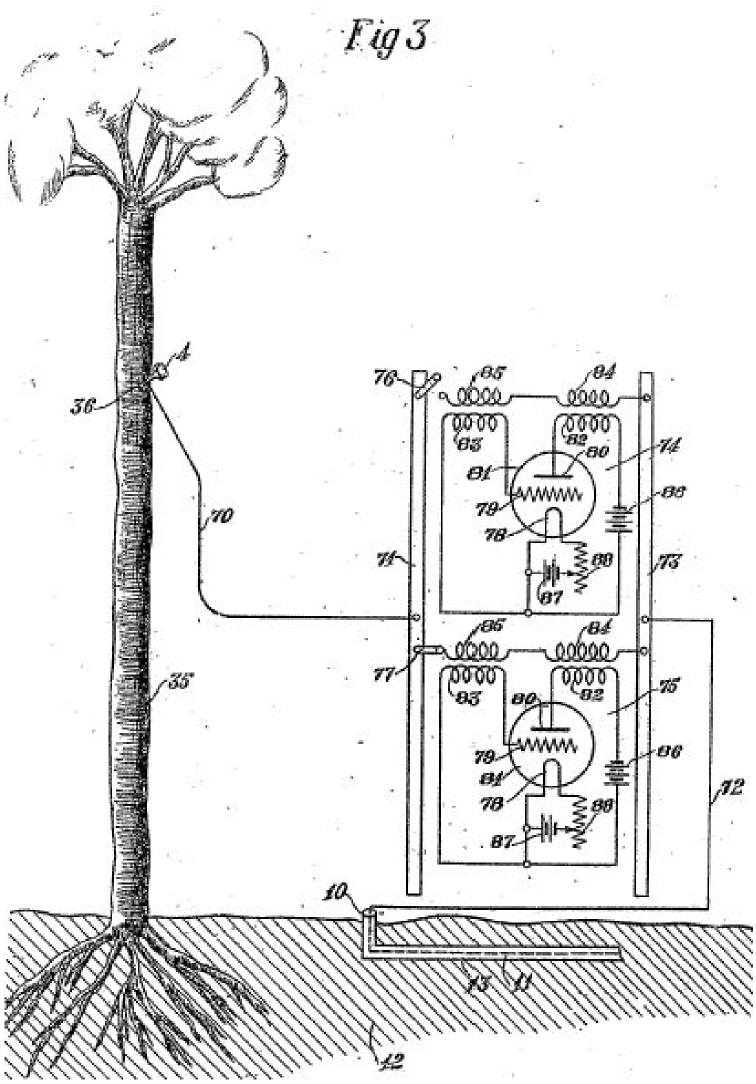


Figure 3 is a diagrammatic view of a preferred form of an arrangement of transmission sets embodying my invention.

Fig 3



Referring to Figure 1, the circuit designated 1 represents any approved form of resonant receiving circuit comprising the variable condenser 2, and detector, rectifier or amplifier 3, arranged with a telephone or any suitable recording device in the usual manner. Such attuned receiving circuit 1 is suitably coupled through transformer windings or otherwise with proper regulatable reactance with the tree or other living vegetable organism and in Figure 1 I have indicated the location 4 as representing the location of a metallic nail, or equivalent, affixed to and extending within the body of such tree. I have discovered that optimum results for any particular tree are dependent upon the physical contour of the space occupied by the branches and leaves as well as the subterranean portions of the tree such as the roots and that generally the optimum results are attained by affixing the nail 4 within the region of the tree substantially two-thirds of the height of the tree above the surface of the earth.

To such nail 4 is connected one end of the lead-in wire 5, preferably enclosed in suitable insulation, and connected at its other end with the resonant circuit 6 comprising the adjustable inductance coil 7 and the adjustable condenser 8. The lead 9 connects the circuit 6 with the counterpoise 10, preferably comprising one or more metallic wires, 11, extending substantially rectilinearly and electrically insulated from the earth 12 by means of suitable insulation 13, as by enclosing such wire or wires 11 within a suitable insulating coating. Such coating 13 extends preferably an appreciable distance above the surface 14 of the earth 12. In the use of my invention with living antennae, I have arranged the counterpoise 10-13 extending in the rectilinear direction substantially parallel to the plane passing through the transmitting station, the receiving station and the center of the earth. It is advantageous to arrange a plurality of individual counterpoises 10

radiating in different rectilinear directions, with a suitable switching device for connecting the lead 9 with the particular counterpoise parallel to or most closely parallel to the selected direction.

Such coil 7 is preferably a primary coil suitably spacially coupled with an adjustable secondary coil 15 connected in the circuit comprising the variable condenser 2 and 3. In the specific form of the invention shown in Figure 1, such secondary coil 15 is provided with the lead wire 16 connected to the terminal 17 of the reversing switch 18 (shown diagrammatically) the other end of the secondary coil 15 being connected by the cross wire 20 of the reversing switch 18. Such terminal 17 is connected by the cross wire 21 with the terminal 24. The pivoted knife blades 25, 26, having the handle 27, are mounted in the usual manner on the central terminals 28, 29. The coil 30 represents diagrammatically a coil comprising a desired number of windings or successive turns of exposed or insulation covered wire, each turn lying substantially in a common vertical plane and the coil indicated at 31 represents a similar plurality of turns of windings mounted in substantially a common vertical plane. One terminal of the coil 30 is connected with one of the central terminals of the reversing switch 18, say terminal 28, and one terminal of the coil 31 is connected with the other central terminal 29, of the reversing switch 18. The other terminal of the coil 30 is connected by the wire 32 with the leads of the variable condenser 2 in shunt with the detector or amplifier 3, while the other terminal of the coil 31 is connected by the wire 33 to the opposite lead of the variable condenser 2 and the detector or amplifier 3.

Such set of coils 30, 31 are suitably mounted to be rotated horizontally, whereby all turns of the coils 30, 31, at any given position lie substantially in a common vertical plane. Such coils 30, 31 may be arranged on a common wooden or like insulating frame of cylindrical, rectangular or other desired contour on cross section.

By virtue of such an arrangement, the primary and secondary circuits are respectively directly exposed to and simultaneously electromagnetically acted upon by the incoming oscillations, and by means of the reversing switch 18 the oscillations generated in the coil 30 may be neutralized or accumulated relatively to the oscillation generated in the coil 31 to produce either the "barrage" or the "amplifying" effect.

By means of such "barrage" effect, the oscillations of any given wavelength directed in any absolute direction are cut out from the detector or amplifying circuit and enable oscillations of similar or the same wave length received in any definite direction to be conducted to the detector or amplifying circuit. By means of such accumulating effect of the coils 30, 31, and the switch 18, the waves of any definite wavelength received in any definite absolute direction are amplified and enable long distance reception at any wave length.

In practice, I have carried out the invention for reception by the use of either a single receiving set or a plurality of receiving sets. Such receiving set or sets may be arranged either to receive damped high frequency oscillations or undamped high frequency oscillations.

In Figure 2 I have illustrated diagrammatically one form of the application of the invention for the simultaneous reception of a plurality of different trains of high frequency oscillations.

The nail 4 is indicated as located in electrical connection with the tree 35 at an optimum point 36, the lead-in wire 37 being connected at its upper end with the nail 4 and at its lower end with the incoming connector bar 38. The connector 38 is provided with the individual switches 39-40-41, etc., corresponding to the number of individual receiving sets. The outgoing connector bar 42 is connected by the lead 43 with the counterpoise 10, preferably constructed and arranged as set forth hereinabove.

In suitable relation with the incoming connector bar 38 and outgoing connector bar 42 and the switches 39, 40, 41 are arranged the respective primary coils 44, 45, 46, etc., respectively coupled in any approved arrangement with the secondary coils 47, 48, 49.

The receiving set 50 is arranged for the reception of undamped waves and is shown of the vacuum tube valve type. The terminals of the secondary 47 are suitably connected in the input circuit including the filament cathode 51 of the vacuum valve 52 and the grid 53 and comprises the variable condenser 54 in shunt with the secondary 47, the condenser 55 and the grid leak resistance 56. The output circuit comprises the battery 58, the filament cathode 51, and the telephone receiver or other audible, or any visual indicator 57. The heating circuit of the filament cathode includes the battery 60 and the variable resistance 61.

The receiving set 62 is shown of a similar undamped oscillation receiving type and like elements are designated by like reference numbers.

The receiving set 63 is indicated of the damped oscillation receiving type and comprises the additional inductance turns 64 having one terminal connected to one terminal of the filament cathode 51 and its other terminal connected to the variable condenser 65 in shunt with the telephone receiver 57 and the storage battery 58. The remaining elements of the receiving set 63 correspond to like elements of the receiving set 50 and are designated by like reference numbers.

In Figure 2 I have shown the switch 39 in closed position with the primary inductance 44 of the receiving set 50, the switch 40 in closed position with the primary inductance 45 of the receiving set 63 and the switch 41 in open position with the primary inductance 46 of the receiving set 62, and accordingly enabling the reception and detection of undamped oscillations of the frequency to which the receiving set 50 is tuned and simultaneously the reception and detection of damped oscillations of the frequency to which the receiving set 53 is tuned.

Figure 3 shows one form of practical application of my invention for transmitting simultaneously radio oscillations, either telephonic or telegraphic, either damped or undamped, or both. The nail 4, lodged at an optimum point 36 in the tree 35, is connected by the lead 70 to the connector bar 71, and the counterpoise 10 is connected by the lead 72 to the connector bar 73.

The transmitting sets 74, 75, etc., of the desired number, are suitably arranged for single or multiple transmission, for which purpose the switches 76, 77, etc., are provided. The transmitting sets 74, 75 are shown of any approved type, such as the oscillating vacuum tube type comprising the filament cathode 78, the grid 79 and anode 80, arranged in the vacuum tube 81, suitably connected with the primary inductance 84, 85. The primary inductances 84, 85 are suitably connected to the connector bar 73 and the connector bar 71 through the respective switches 76, 77. The battery or other source of electric current is indicated at 86. The adjustable heating circuit of the cathode filament 79 is shown comprising the battery 87 and the variable resistance 88.

In Figure 3, the switch 77 is in closed position thus placing the transmitting set 75 in operative connection with the tree serving as the antenna. Upon closing the switch 76 the transmitting set 74 is similarly placed in operative connection with the tree antenna 35. Upon closure of both switches 76, 77 the tree serves as the antenna for the transmission of simultaneous trains of oscillations emitted by the respective transmitting sets 74, 75, modified by a key or telephone transmitter, or other suitable modulator, for the transmission of telegraphic or telephonic messages as desired.

In the use of trees or other living vegetable organisms serving as the antenna or a art thereof, I have discovered from tests that such tree possess impedance consisting of two components, resistance and reactance, the latter being usually condensive, for oscillation within the range of present day wavelengths. The tests also show that the apparent capacity of a tree serving as an antenna is substantially proportional to the height of contact of the lead wire connecting the transmission set with the tree.

The tests also show that the apparent resistance of a tree serving as an antenna is appreciably greater than the resistance of the ordinary metallic antenna, and it is accordingly desirable to modify the resistance or alter the design of the receivers, if it desired to increase the effectiveness of the energy of the electromagnetic radiation impinging on the tree; however, the ordinary receivers of present design may be used and are responsive to any wave length of radiation employed in present day practice.

Whereas I have described my invention by reference to specific forms thereof, it will be understood that many changes and modifications may be made without departing from the spirit of the invention as defined by the appended claims.

An alternative electric power generating system that draws energy from a seemingly unlikely yet abundant, eminently renewable and virtually free power source has been submitted for patenting by MagCap Engineering, LLC, Canton, Mass., in collaboration with Gordon W. Wadle, an inventor from Thomson, Ill. Wadle has invented a way to capture the energy generated by a living non- animal organism --- such as a tree.

Source: KeelyNet / Jerry Decker email (12/21/05)

"Unlimited Electric Energy from the Environment?"

Chris Lagadinos, president of MagCap, developed circuitry that converts this natural energy source into useable DC power capable of sustaining a continuous current to charge and maintain a battery at full charge.

"As unbelievable as it sounds, we've been able to demonstrate the feasibility of generating electricity in this manner," said Wadle.

"While the development is in its infancy, it has the potential to provide an unlimited supply of constant, clean energy without relying on fossil fuels, a power generating plant complex or an elaborate transmission network."

Wadle likened the invention to the discovery of electricity over 200 years ago when charged particles were harnessed to create an electric current. "Now we've learned that there is an immense, inexhaustible source of energy literally all around us that can be harnessed and converted into usable electric power," he said. Ultimately, it should prove to be more practical than solar energy or wind power, and certainly more affordable than fuel cells, he added.

Wadle said he got the original idea of harnessing a tree for electrical energy from studying lightening, more than 50 percent of which originates from the ground. This prompted him to develop the theories resulting in a method to access this power source.

Lagadinos then designed circuitry that filtered and amplified these energy emanations, creating a useable power source.

Basically, the existing system includes a metal rod embedded in the tree, a grounding rod driven into the ground, and the connecting circuitry, which filters and boosts the power output sufficient to charge a battery.

In its current experimental configuration, the demonstration system produces 2.1 volts, enough to continuously maintain a full charge in a nickel cadmium battery attached to an LED light. "Think of the environment as a battery, in this case," said Lagadinos, "with the tree as the positive pole and the grounding rod as the negative."

Lagadinos said the system could be enhanced enough to generate 12 volts and one amp of power, "a desirable power level that could be used to power just about anything," he said. It is enough power to charge batteries for any type of vehicle, including hybrids and electric cars, or to use with an AC converter to produce household power, he added. The LED industry is a prime example of a potential user of this power source.

While the basic concept of this invention -- using a tree to generate electric power -- seems too incredible to be true, Lagadinos said it can be demonstrated quite simply. "Simply drive an aluminum roofing nail through the bark and into the wood of a tree -- any tree -- approximately one half inch; drive a copper water pipe six or seven inches into the ground, then get a standard off-the-shelf digital volt meter and attach one probe to the pipe, the other to the nail and you'll get a reading of anywhere from 0.8 to 1.2 volts of DC power," he said.

"You can't do anything with it in that form because it is 'dirty' -- i.e. highly unstable and too weak to power anything," he added. In order to properly harness this potential energy source, MagCap devised two test circuits: one with three capacitors that were connected in parallel by means of a switch and charged to 0.7 volts each.

When fully charged they are switched to a series mode, multiplying the voltage to 2.1 volts and flashing an LED to show that sufficient power could be generated to produce a useable result. The second circuit included a filtering device to stabilize and "clean" the current so it could be used to charge and maintain a NiCad battery.

The battery then could be connected to the LED to keep the LED lit continuously. Wadle pointed out that there seems to be no limit to the amount of power that can be drawn from an individual tree, no matter how many "taps" are inserted -- each produces the same amount of energy, an average of 0.7 - 0.8 volts. Size of the tree also seems not to matter.

Interestingly, while conventional wisdom would seem to indicate that the tree draws much of its energy from photosynthesis via its leaves, the voltage output actually increases to 1.2-1.3 volts in the winter after the leaves have fallen.

Patents by George O. Squire:

Apparatus for using telephone-subscribers' loops for transmission and reception of broadcasting
SQUIER GEORGE O
EC: H04H1/08 IPC: H04H1/08; H04H1/04
US1742422
1930-01-07

Apparatus for effecting electrical signaling
SQUIER GEORGE O; LOUIS COHEN
EC: H04L27/06 IPC: H04L27/06; H04L27/06
US1608252
1926-11-23

Aerial attachment device for radiofrequency signal systems
SQUIER GEORGE
EC: H01Q1/46 IPC: H01Q1/46; H01Q1/44
Publication info: US1584197
1926-05-11

Electrical signaling
SQUIER GEORGE O; MAUBORGNE JOSEPH O
EC: H01F21/02 IPC: H01F21/02; H01F21/02
US1641608
1927-09-06

Apparatus for electrical signaling
SQUIER GEORGE
EC: H04B1/034 IPC: H04B1/034; H04B1/02
US1531629
1925-03-31

Improvements in the Art of Telegraphy
SQUIER GEORGE OWEN; AUSTIN LOUIS WINSLOW
EC: H04J1/00 IPC: H04J1/00; H04J1/00
GB108763
1917-08-23

Improvements in the Art of Electrical Signalling
SQUIER GEORGE; AUSTIN LOUIS WINSLOW
EC: H04J1/00 IPC: H04J1/00; H04J1/00
GB108230
1917-08-02

Improvements in Duplex and Multiplex Telegraphy
SQUIER GEORGE; COHEN LOUIS
EC: H04J1/00 IPC: H04J1/00; H04J1/00

GB103771
1917-02-08

Combined sound and light distributing apparatus
SQUIER GEORGE
EC: F21V33/00; H05K11/00 IPC: F21V33/00; H05K11/00; F21V33/00 (+1)
US1999579
1935-04-30

Radio signaling apparatus
SQUIER GEORGE
EC: H04B3/56 IPC: H04B3/56; H04B3/54
US1791541
1931-02-10

Improvements in or relating to Receiving Systems for Radio Telegraphy or Telephony
SQUIER GEORGE
EC: H01Q1/46; H04H1/04 IPC: H01Q1/46; H04H1/04; H01Q1/44 (+1)
GB191417487
1914-11-19

Improvements in or relating to Radio-telegraphic and Radio-telephonic Receiving Systems
SQUIER GEORGE
EC: H04M11/06 IPC: H04M11/06; H04M11/06
GB191403191
1915-02-08

Improvements in or connected with Multiplex Telephony and Telegraphy
SQUIER GEORGE
EC: H04J1/00 IPC: H04J1/00; H04J1/00
GB191030003
1911-12-27

Improvements in or relating to Receiving Systems for Radio Telegraphy or Telephony
SQUIER GEORGE
EC: H01Q1/46; H04H1/04 IPC: H01Q1/46; H04H1/04; H01Q1/44 (+1)
GB191417487
1914-11-19

Improvements in or relating to Radio-telegraphic and Radio-telephonic Receiving Systems
SQUIER GEORGE
EC: H04M11/06 IPC: H04M11/06; H04M11/06
GB191403191
1915-02-08

Improvements in or connected with Multiplex Telephony and Telegraphy
SQUIER GEORGE
EC: H04J1/00 IPC: H04J1/00; H04J1/00
GB191030003
1911-12-27

Improvements in or connected with Telegraphic Apparatus
CREHORE ALBERT CUSHING (US); SQUIER GEORGE
GB189919867
1900-10-03

Improvements in Telegraphic Apparatus
CREHORE ALBERT CUSHING (US); SQUIER GEORGE

GB189918980
1900-09-20

Improvements in Telegraphic Apparatus
CREHORE ALBERT CUSHING (US); SQUIER GEORGE
GB189917722
1900-09-01

Improvements in Submarine Cable Telegraphs
CREHORE ALBERT C (US); SQUIER GEORGE
GB189823556
1900-02-08

Method and apparatus for using telephone subscribers' loops for transmission and reception of broadcasting
SQUIER GEORGE
EC: H04B3/56; H04H1/04 IPC: H04B3/56; H04H1/04; H04B3/54 (+1)
FR644877
1927-10-16

TELEPHONE AND BROADCASTING SYSTEM
SQUIER GEORGE
CA285479
1928-12-11

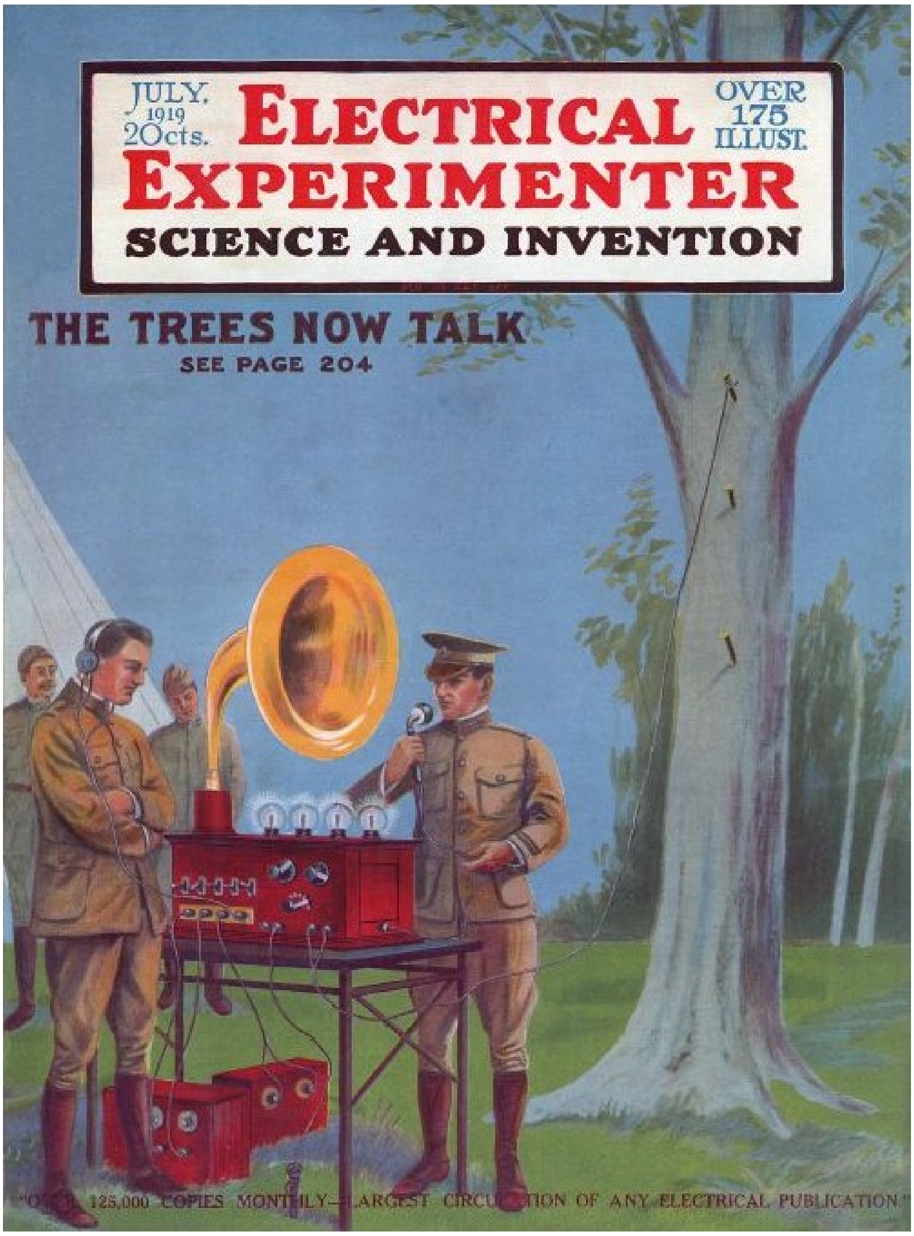
HIGH FREQUENCY CURRENT SIGNALLING
SQUIER GEORGE
CA244330
1924-11-11

ELECTRIC SIGNALLING SYSTEM
SQUIER GEORGE
CA233299
1923-08-07

TREE TELEPHONY AND TELEGRAPHY
SQUIER GEORGE
CA232487
1923-07-03

BLDGBLOG

Tree Receivers



[Image: "The Trees Now Talk" cover story in *The Electrical Experimenter* (July 1919); image via *rexresearch*].

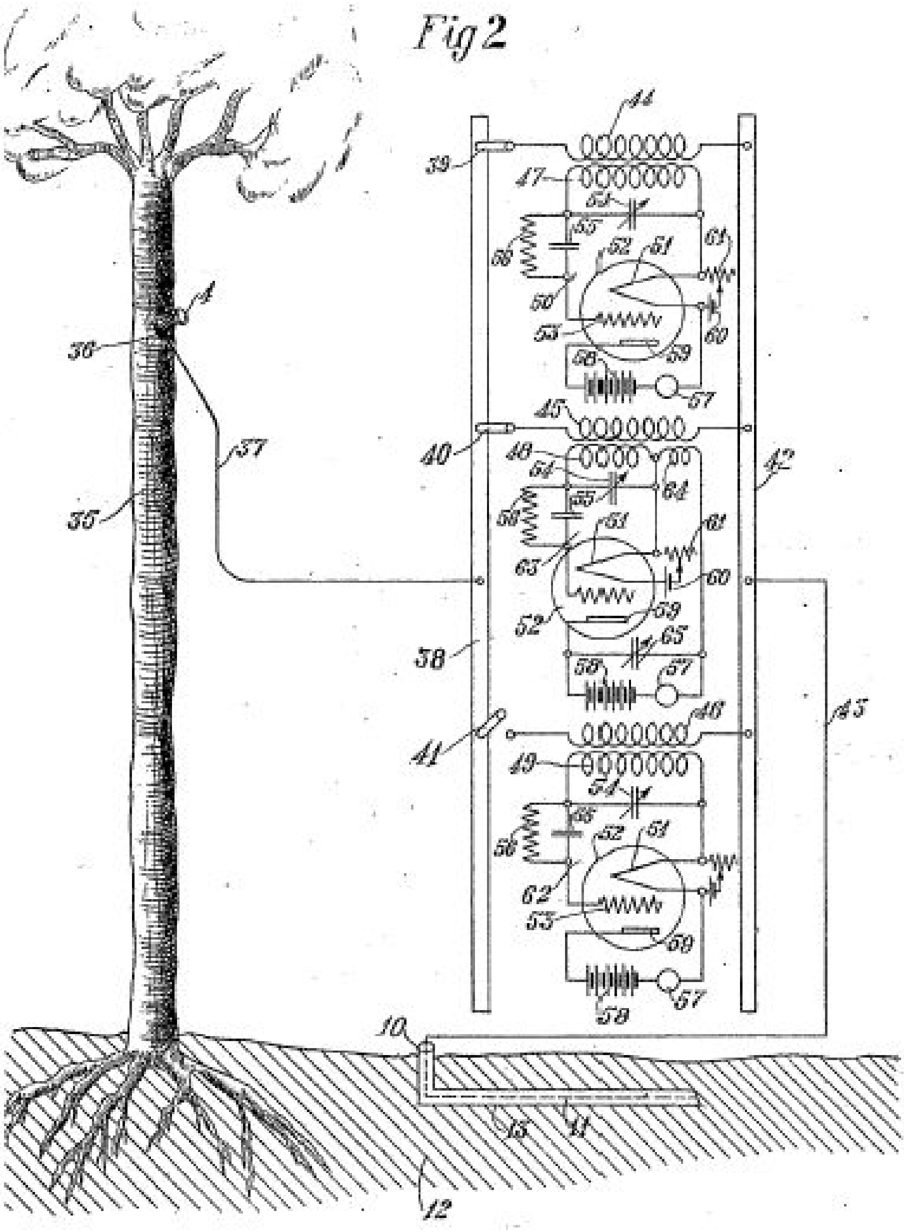
Way back in 1919, in their July 14th issue, *Scientific American* published an article on the discovery that trees can act "as nature's own wireless towers and antenna combined."

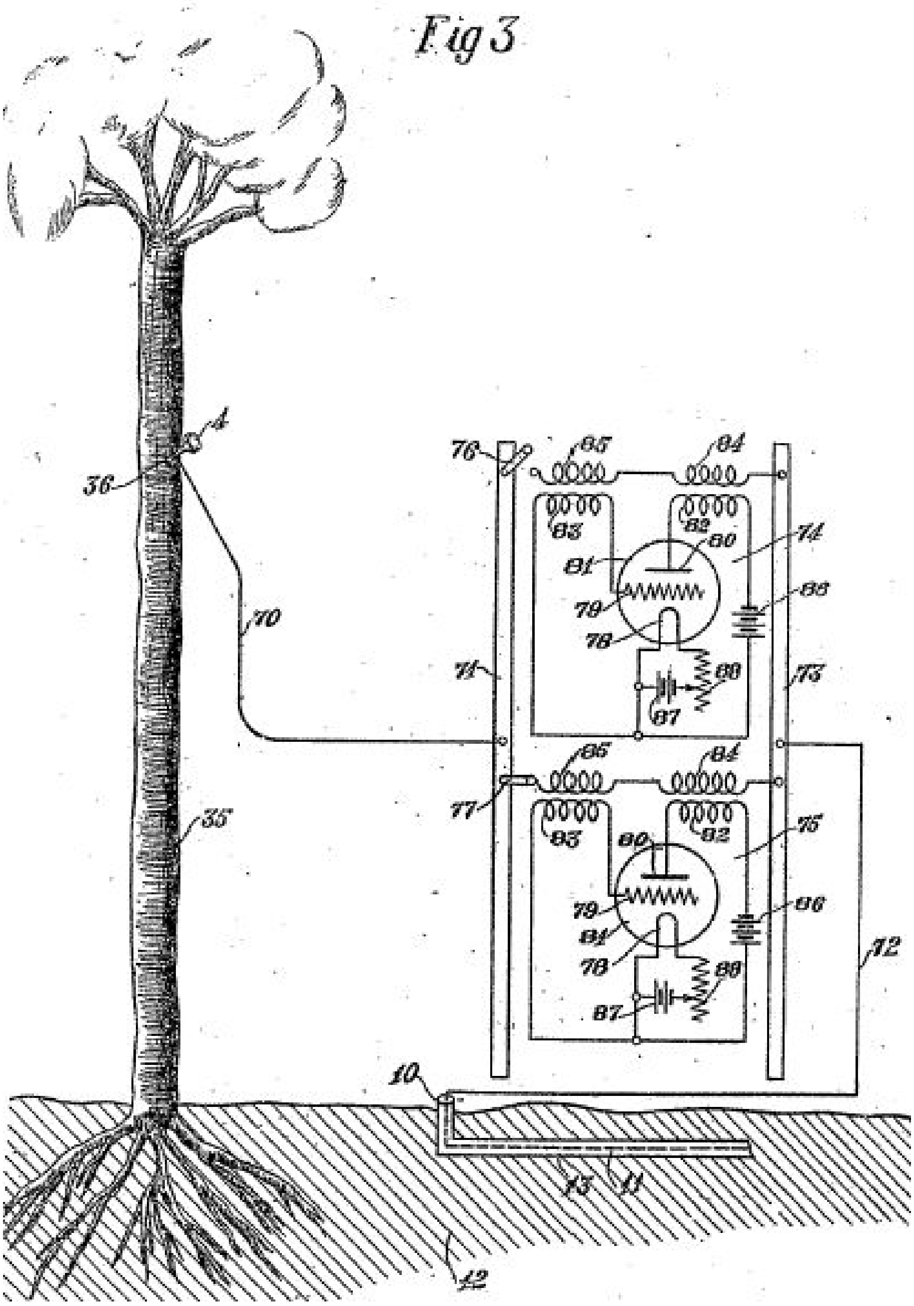
General George Owen Squire, the U.S. Army's Chief Signal Officer, made his "strange discovery," as *SciAm* phrases it, while sitting in "a little portable house erected in thick woods near the edge of the District of Columbia," listening to signals "received through an oak tree for an antenna." This realization, that "trees—all trees, of all kinds and all heights, growing anywhere—are nature's own wireless towers and antenna combined."

He called this "talking through the trees." Indeed, subsequent tests proved that, "[w]ith the remarkably sensitive amplifiers now available, it was not only possible to receive signals from all the principle [sic] European stations through a tree, but it has developed beyond a theory and to a fact that a tree is as good as any man-made aerial, regardless of the size or extent of the latter, and better in the respect that it brings to the operator's ears far less static interference."

Why build a radio station, in a sense, when you could simply plant a forest and wire up its trees?

Fig 2





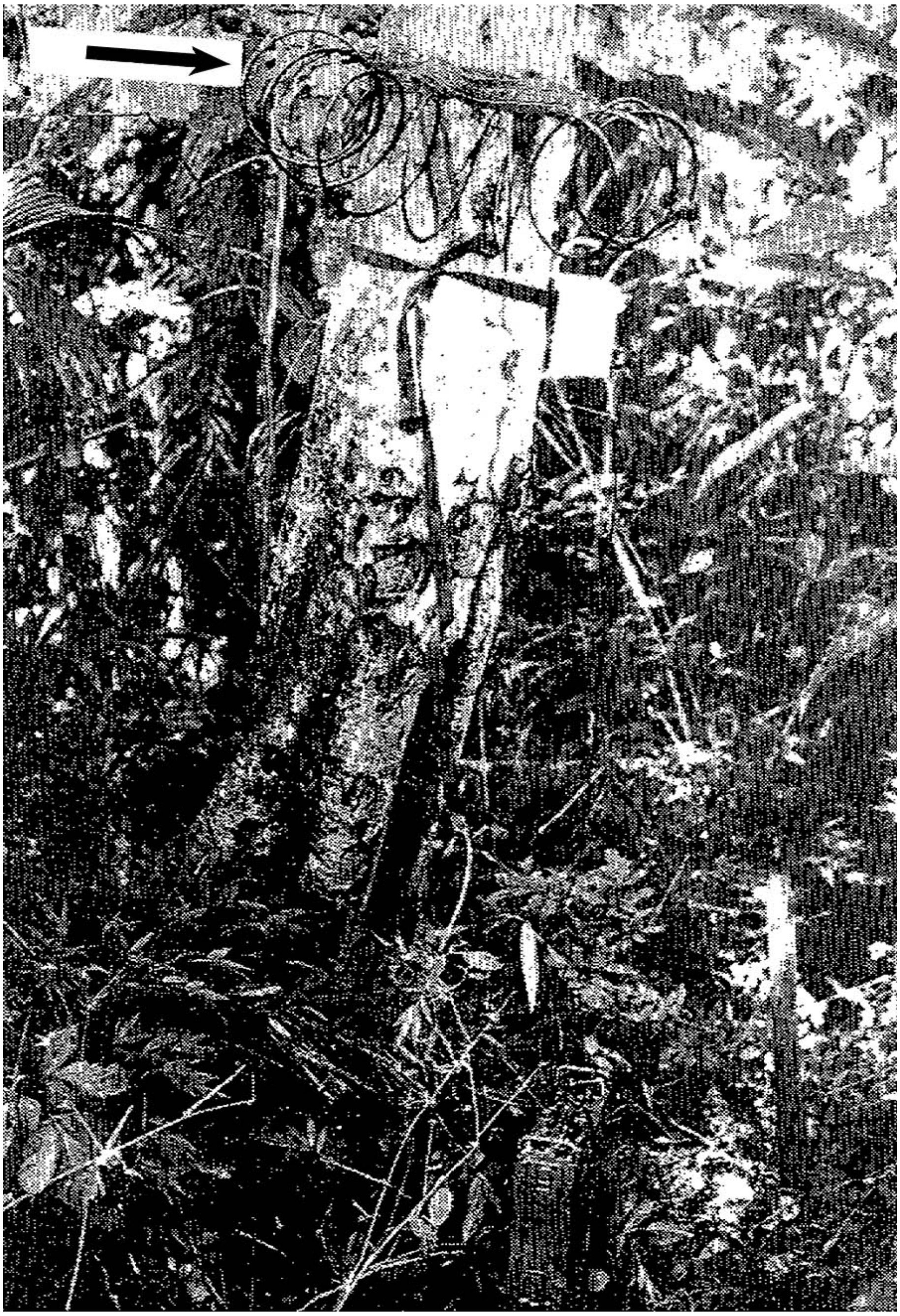
[Images: From George Owen Squire's British Patent Specification #149,917, via *rexresearch*].

So how does it work? Alas, you can't just plug your headphones into a tree trunk—but it's close. From *Scientific American*:

> The method of getting the disturbances in potential from treetop to instrument is so simple as to be almost laughable. One climbs a tree to two-thirds of its height, drives a nail a couple of inches into the tree, hangs a wire

> therefrom, and attaches the wire to the receiving apparatus as if it were a regular lead-in from a lofty copper or aluminum aerial. Apparently some of the etheric disturbances passing from treetop to ground through the tree are diverted through the wire—and the thermionic tube most efficiently does the rest.

Although "40 nails apparently produce no clearer signals than half a dozen," one tree can nonetheless "serve as a receiving station for several sets, either connected in series with the same material or from separate terminals."



[Image: Researching the possibility that whole forests could be used as radio stations—broadcasting weather reports, news from the front lines of war, and much else besides—is described by *Scientific American* as performing "tree radio work." Image via *IEEE Transactions on Antennas and Propagation* (January 1975)].

In a patent filing called "British Patent Specification #149,917," Squire goes on to explore the somewhat mind-bending possibilities offered by "radio transmission and reception through the use of living vegetable organisms such as trees, plants, and the like." He writes:

> I have recently discovered that living vegetable organisms generally are adapted for transmission and reception of radio or high frequency oscillations, whether damped or undamped, with the use of a suitable counterpoise. I have further discovered that such living organisms are adapted for respectively transmitting or receiving a plurality of separate trains of radio or high frequency oscillations simultaneously, in the communication of either or both telephonic or telegraphic messages.

This research—the field of "tree radio work"—has not disappeared or been forgotten.

[Image: A tree in the Panamanian rain forest wired up as a sending-receiving antenna; from *IEEE Transactions on Antennas and Propagation* (January 1975)].

In the January 1975 issue of *IEEE Transactions on Antennas and Propagation*, we read the test results of several gentleman who went down to the rain forests of the Panama Canal Zone to test "the performance of conventional whip antennas… compared with the performance of trees utilized as antennas in conjunction with hybrid electromagnetic antenna couplers."

The authors specifically cite Squire's work and quote him directly: "'It would seem that living vegetation may play a more important part in electrical phenomena than has been generally supposed… If, as indicated above in these experiments, the earth's surface is already generously provided with efficient antennae, which we have but to utilize for communications…' These words were written in 1904 by Major George 0. Squire, U.S. Army Signal Corps, in a report to the Department of War in connection with military maneuvers in the Pacific Division."

The authors of the *IEEE Transactions* report thus establish up a jungle-radio "Test Area" in a remote corner of Panama, complete with trees wired-up as dual senders & receivers. There, they think they've figured out what's occurring on a large scale, as signals propagate through the forest canopy, writing that we should consider "the jungle as a maze of aperture-coupled screen rooms. In the jungle case, the screens, in the form of vertical tree and fern trunks, and the horizontal forest canopy are of variable thickness, have variable shaped apertures, and are composed of diverse substances that contain mostly water."

[Image: Inside the Panamanian jungle-radio Test Zone; image via *IEEE Transactions on Antennas and Propagation* (January 1975)].

The design implication of all this is that an ideal radio-receiving forest could be planted and maintained, complete with spatially tuned "aperture-coupled screen rooms" (trees of specific branch-density planted at specific distances from one another) to allow for the successful broadcast of messages (and/or music) through the "living vegetable organisms" that Squire wrote about in his patent application.

What other creatures—such as birds, bats, wandering children, foxes, or owls—might make of such a landscape, planted not for aesthetic or even ecological reasons, but for the purpose of smoothly relaying foreign radio stations or encrypted spy communications, is bewildering to contemplate.

In any case, this truly alien vision of forests silently crackling inside with unexploited radio noise is incredible, implying the existence of undiscovered "broadcasts" of biological noise, humming trunk to trunk amongst groves of remote forests like arboreal whale song,

inaudible to human ears, as well as suggesting a near-miraculous venue for future concerts, where music would be played not through wireless headsets or hidden speakers lodged in the woods but *through the actual trees*, music shimmering from root to canopy, filling trees branch and grain with symphonies, drones, rhythms, songs, sounds occasionally breaking through car radios as they speed past on roads nearby.

[All links found via an old message from Shawn Korgan posted to the *Natural Radio VLF Discussion Group* of which I am a non-participating member. Vaguely related: *The Duplicative Forest* and Pruned's *Graffiti as Tactical Urban Wireless Network*. See also a follow-up post: *Antarctic Island Radio*].

Related

Electromagnetic Escher Mazes

January 2, 2013
In "Antennas"

A Voice Moving Over The Waters

May 4, 2017
In "Antennas"

Urban Haunting

June 2, 2009
With 18 comments

Geoff Manaugh / December 31, 2012 / BLDGBLOG / Antennas, Design, Electromagnetism, Forestry, Landscape, Technology, Trees

7 thoughts on “Tree Receivers”

Greg

January 1, 2013 at 7:11 pm

Reminded me of Terry Allen's "Trees" (1986): http://stuartcollection.ucsd.edu/artists/allen.shtml

Anonymous

January 1, 2013 at 8:11 pm

And the length of the metallic wire from the electronics equipment to the nail, 2/3rd of the way up the tree had nothing to do with the capability..... geez......

rypat

January 3, 2013 at 12:32 am

related — Robert Voit's "New Trees" series: http://www.robertvoit.com/bilder/serie1_new_trees/index.php

greg

January 3, 2013 at 4:44 pm

@rypat: thanks.

Eric

January 13, 2013 at 8:03 pm

"In any case, this truly alien vision of forests silently crackling inside with unexploited radio noise is incredible, implying the existence of undiscovered "broadcasts" of biological noise, humming trunk to trunk amongst groves of remote forests like arboreal whale song, inaudible to human ears,"

As an electrical engineer, I must say this is nonsense. The inside of a tree can conduct electricity up to its top, because of the water in it. From an electrical perspective, it is no different from a radio tower. But radio towers don't generate radio signals on their own, and neither do trees. The most you could get out of them is a little background static, which would be overwhelmed by all the other sources of static in the environment.

Otherwise, very interesting article.

Dominic Hunt

January 19, 2013 at 2:48 pm

Reminds me of some of the work Disney was doing on making plants multi-touch interaction surfaces. http://www.fastcodesign.com/1670595/disney-turns-houseplants-into-multi-touch-surfaces#-1

Anonymous

March 16, 2013 at 4:36 pm

interesting. did you know they have cell phone towers disguised as trees now? they look incredibly fake: http://twistedsifter.files.wordpress.com/2012/08/cell-phone-tree-2.jpg

Tune Around!
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Antenna Safety!
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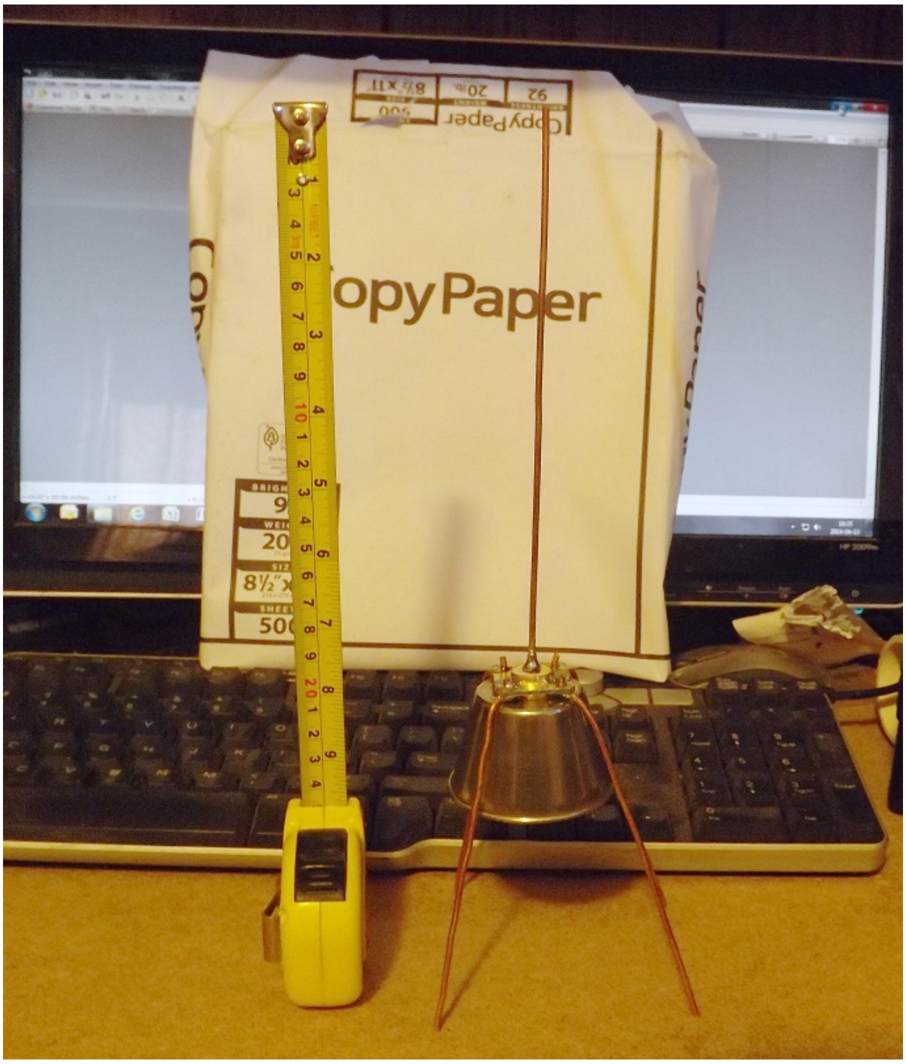
The AA7BM 440/70cm Ground Plane "Tea Cup" Antenna Project

Well, it is starting to get warm and the Arizona sun must have fried what few brains I thought I had as I was thinking that no one makes miniature antennas unless they are doing portable QRP so I decided I wanted to make a 70cm ground plane, just to see if I could.



I do not do QRP or even much portable and my portable has a perfectly fine ducky that works very well thank you, so the only reason I have to make a tiny antenna is because I have some space to let in the upstairs attic.

Anyway, I call it a tea cup antenna as the cup I used is just a bit smaller than an oriental tea cup.

I started with approximately a 30 inches piece of #12 THNN, and stripped the insulation off it.

Stainless Steel Condiment cups by Mainstays at Wally World

I purchased a package of four stainless steel condiment cups as shown in the photo above from Wally world and drilled a 5/8ths inch hole in one of them, turned it upside down, then I dropped the SO-239 down into that from the top.

I then cut four eight inch pieces from my wire, and rolled them between the counter top and a piece of wood to get them fairly straight. I then took a pair of needle nose and bent the tip of these four wires 90 degrees. Placing them between the cup and the SO-239 with the bent tips coming up through the mounting holes, I then soldered them in place. I had my radials. See photo below.

I drilled a hole in the mount for a self tapping screw to secure the mount to the cup (still have not done that as it works fine without it).

I then took the remainder of my wire, straightened it out like I did the radials, and soldered it to the center pin of the SO-239.

I connected a short jumper to the SO-239, (a bit tricky inside that cup with my fat fingers) and dropped the co-ax down thru a short piece of 3/4" PVC. I then put the antenna on top of the PVC and hooked it to my MFJ-269 and did the clip and bend technique until I got the SWR down as low as I could for the 440 repeater on Heliograph Peak 45 miles away.

I put an adaptor on the end of the coax to fit my HT and held it in my left hand. I then put the HT in my right hand, dialed in the 440.700 repeater and asked for a test. N7AM in Pima, AZ came right back and told me I was getting out. I thanked him and cleared, but immediately had another call from a man in Holbrook who said I was full quieting on his HT there.

This took me about an hour to make, and another 1/2 hour to tune for the 440-448 band. I had intended to make it a 5/8 wave, but didn't have enough wire so I ended up with only enough wire on the vertical to make what appears to be a 1/4 wave ground plane antenna.

The only real cost was for the SO-239.. everything else besides the stainless steel condiment cup came from the junk pile. The stainless steel condiment cup was only 79 cents at Wally world for a pack of 4.

Hmm, I still have 3 more condiment cups, can I do the same thing for 2 meters? What about 6 or 10?

B. McCabe, AA7BM
San Simon, AZ
(formerly KG7GTE)

Also see his 2 Meter Slim Jim antenna project here under a previous call sign!

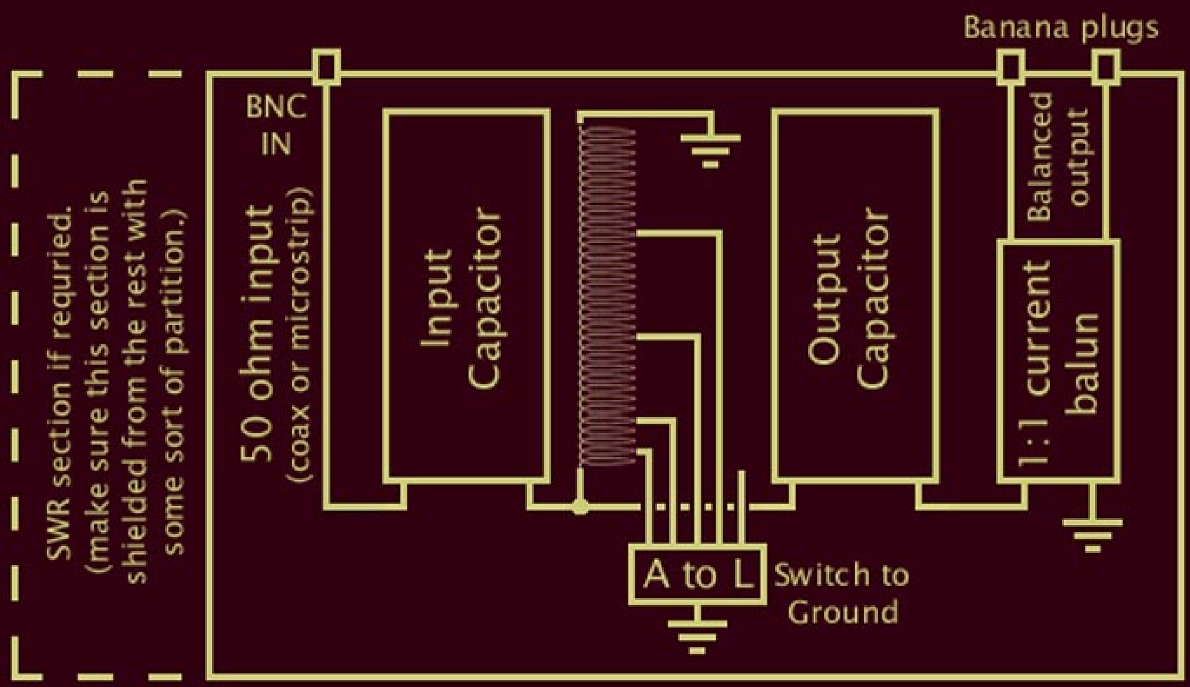
LAYOUT	IT IS STRONGLY RECOMMENDED A 50 OHM IMPEDANCE IS MAINTAINED RIGHT UP TO THE INPUT CAPACITOR CONNECTION. Both tuner Mark 2 and Mark 3 do this by using a 50 ohm SWR pickup as the input connection but if you decide not to include a SWR meter, the use of 50 ohm coax is recommended. See also GENERAL LAYOUT BELOW
INPUTS	IT IS STRONGLY RECOMMENDED ONLY A SINGLE INPUT SOCKET IS USED AND THAT IT IS A BNC CONNECTOR. To use more involves switches and wires that may cause problems. The tuner will match impedances after the input capacitor but not before. A PLC-259 or BNC connector will both handle 500 volts. Since the input side will be 50 ohms, powers of up to 500^2 / 50 = 5kW are possible with these connectors. Current at this power is 10 amps if transmitting carrier but only 2.5 to 3 amps using SSB (based on the average human voice without compression). A BNC will handle this fine.
OUTPUTS	IF YOU USE A TUNER, THE ONLY COAX YOU SHOULD USE IS BETWEEN IT AND THE RADIO OR AMPLIFIER. A tuner is only suitable to two types of antenna viz. 1) a single long wire using ground as the counterpoise and 2) a balanced antenna of some kind. Even though this is an unbalanced tuner, there is little point using an unbalanced output (coax). The SWR on the input side of the tuner may be 1:1 but on the output it is the same as it was without the tuner and losses the same. Since coax over 1.5:1 introduces too many losses, IT IS STRONGLY RECOMMENDED A 1:1 CURRENT BALUN IS INCLUDED in these units especially if the long wire option is chosen because it is more easily bypassed than a voltage balun. See balun options below.
BALUN	Note first, the terms "voltage balun" and "current balun" are as defined on this site. So long as there are delusions that current and voltage can be transformed (or transferred) as separate entities, this controversy will exist. Voltage baluns have transfer losses while current baluns don't other than the resistance of the wire. A 1:1 CURRENT BALUN IS RECOMMENDED.
CAPACITORS	The usual tendency for amateurs is to get something too big. It is totally pointless getting 3kV spacing capacitors if the rest of the tuner is limited to 100 volts. In fact, if the rest of the tuner will only handle 100 volts, there are advantages in getting capacitors of the same rating. The largest voltage, other than across the coil, is likely to be across the input capacitor which is usually smaller to slightly bigger than at the output terminals. If you have a PL-259 on the output (not recommended at all) then there is no point getting big capacitors. 500 volt spacing is fine because that's all a PL-259 will handle. IT IS HIGHLY RECOMMENDED THE SMALLEST (IN PHYSICAL SIZE) CAPACITORS ARE USED FOR THE POWER YOU NEED. There will be less losses because of stray resistance and/or inductance. Maximum capacitance can be anywhere from 350 to 500 pF. Minimum doesn't matter so much because there always must be some.
COIL	The coil is where all the power is consumed so the thicker the better. Silver plating this component is also a very good idea. For high power it is advisable to wind the coil with 6mm copper tube. For 160m use, the inductance required will be about 30uH. For 80m and above 15-20uH while 40m and above 8-10uH. IT IS STRONGLY RECOMMENDED TO

MAKE TO COIL NO BIGGER IN INDUCTANCE THAN REQUIRED. An approximation calculator in the form of an XLS speadsheet has been provided in downloads below.

GETTING THE BITS

The general population seems to be dumb these days and people don't do things for themselves or make things anymore so getting the tuning capacitors and other parts was like finding a needle in a haystack but I eventually got a couple. Be prepared for a search in your own city. In Adelaide Australia, they are available from Cookson Controls.

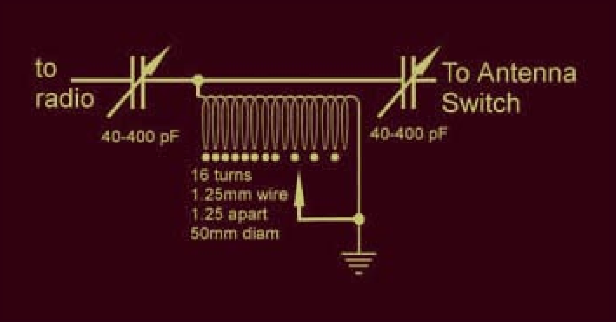
GENERAL LAYOUT



1) The two connections to the capacitors should be made at the same end of the device. This will reduce series inductance and therefore losses especially at the higher frequencies.
2) The shorter used parts of the coil (least inductance) should be kept to the front of the enclosure to keep the connections to the switch as short as possible.
3) Because of 1) and 2) above, the capacitors should be connected towards the front of the box.
4) A BNC or N-connector are recommended, the BNC for lower power tuners and the N-connector for larger power levels.
5) If a SWR meter is included, the micro-stripline needs to be as long as possible so having the capacitor input connection at the front is an advantage. This should be a 50 ohm micro-strip (6mm wide). If the SWR meter is not included, 50 ohm coaxial cable should be used especially for the higher frequensies.
6) Grounding the of the coil away from the switch grounds both ends of the unused part of the coil. This will increase losses. This is better than having self oscillations because of capacitive coupling between the turns. It will also prevent having massive voltages on the unused free end on the

higher frequencies. The magnetic influence of any winding will not extend more than a few turns keeping losses down.

TUNER MARK 1



The circuit is fairly simple but construction a lot more difficult so this page will concentrate on that aspect. The box is made from PCB material off-cuts.

MAKING THE COIL

The coil was the most difficult to get right. I first searched the backyard and found a piece of water pipe of about the correct diameter (50mm). I got some 1.25 mm winding wire from an old transformer and straightened it out. To do this simply hold one end in a vice and the other with some pliers in your hand and give it a SMALL stretch. Sometimes this works on wire you want to re-use but it can crack the insulation and degrade the voltage specs so be careful. For this application it doesn't matter.

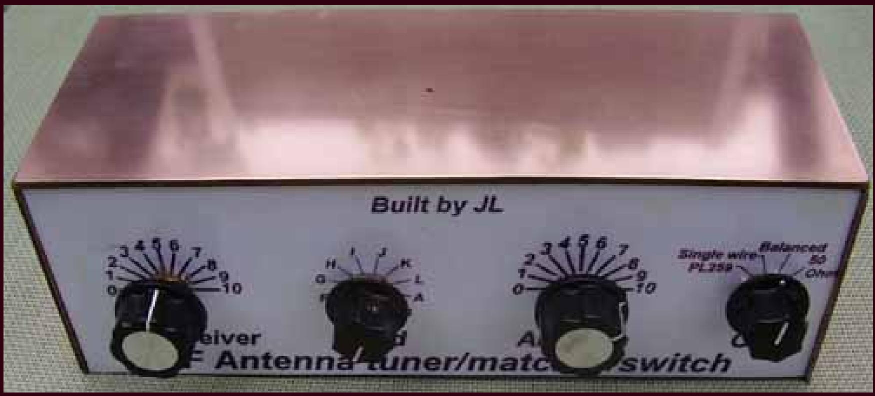
I then wrapped the pipe up with a couple of layers of paper and cling wrap. I placed a DOUBLE winding along the pipe for 20 odd turns. Only 14 or so are needed for 80 metres but I gave myself headroom. The ends of the wire were stuck down with tape. The turns were then carefully pulled together. I then used some polystyrene body filler and ran a couple of lines along the coil spaced at 1/3 intervals along the circumference. These must not be too wide because they are used to hold it together only. Air makes a much better dielectric. Once dry, I pulled one winding off breaking the polystyrene as I went but leaving enough to keep the other winding in tact and evenly spaced 1.2mm apart.

Once the middle winding is stripped out, I ran another line of polystyrene along the same places as I did before and CAREFULLY slid the coil off the pipe. Once I removed the inner paper, the coil slid easily back over the pipe. I could then use a power wire brush to strip the insulation from along one gap between the polystyrene so the band connections could be made for the switch.

PUTTING IT ALL TOGETHER

Construction is exactly as shown in the picture above. The coil is held down with hot melt glue using a small standoff made of plastic. Since the tuner will do all the impedance matching needed, only a simple 1:1 current balun is needed to convert to balanced line.

The only thing now is the front panel but, before that, it is a good idea to first to polish all the external exposed copper. A coat of clear lacquer will keep the unit looking nice. The front panel was drawn up in a few minutes with PhotoShop. The panel design was then printed out and laminated with an extra piece of paper behind it. When it is cut out, the back lamination comes away and the paper side can be simply glued to the box with suitable glue.



Completed unit

Costs:-

Capacitors $80
PCB box about $15 depending on where you get it.
Coil - nothing
Switches, chassis sockets - $15
Knobs etc. - $5
Powdered iron toroid for balun $10
TOTAL $115. How much did you pay for your tuner?

TUNER MARK 2

THE NEED TO CHANGE

The problem I had with tuner mark 1 was only on 160 metres. It worked very well at everything from 80 metres to 6m and I used it for some time on all bands between. On 160 metres space limitations mean my antenna simply isn't high enough to have a reasonable pattern to work DX but that's not of concern to a tuner.

A new tuner housing had to be made to accommodate a larger coil. This housing was still less than enough to make micro-strip SWR pick-ups suitable for 40m or less so an opamp was used to amplify the signals from the pick-ups. This can be switched in or out as required. On about 20m (10 watts) and

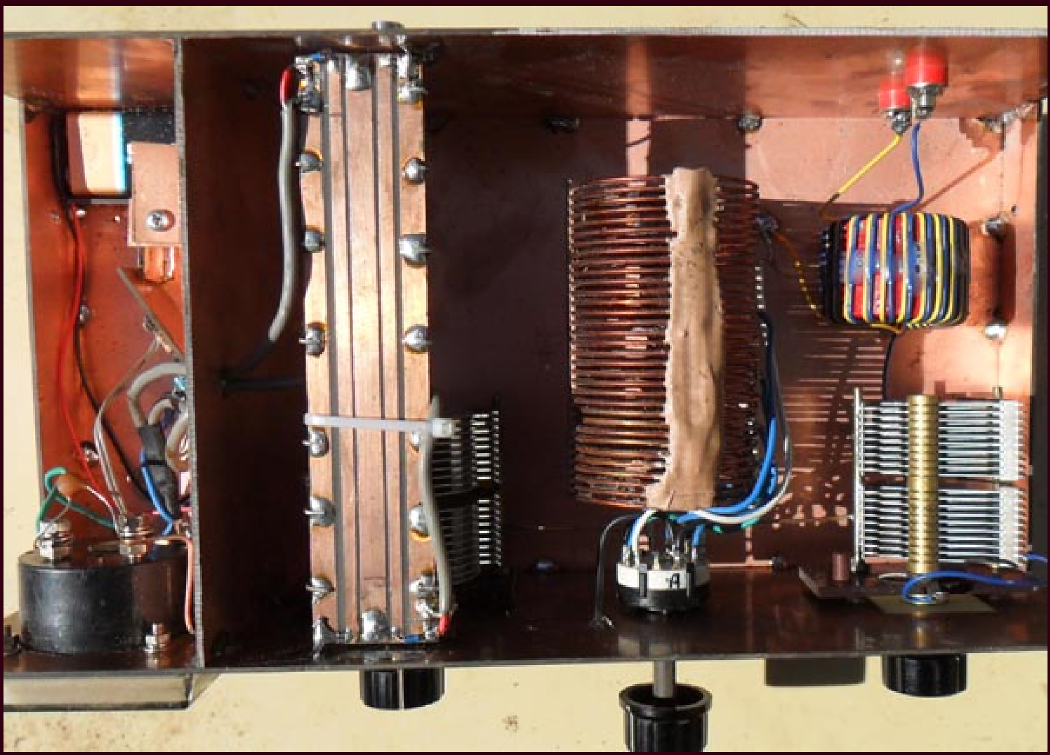
up to 2m (200mW), the op-amp doesn't need to be used. On 40m to 160m, the op-amp can still be avoided but calibration of the meter for correct SWR reading can't be achieved. On the other hand, by switching to REFlected, an antenna can be tuned by simply finding the minimum reading.

The inbuilt SWR meter follows that on my HF radio quite closely. On some bands it is a bit out but if it reads less than 1.1:1, the one on the radio is less than 1.3:1 or vice versa. {uThe linear amplifier is more happy when the inbuilt SWR meter on the tuner is used rather than the one in the radio.}

MAJOR CHANGE

The major change was the size of the coil. This was increased to 32 turns of the same construction. The first take off point is ½ turn from the start of the coil and moves in progressively larger steps from one to 8 turns for the last. New taps are at 1, 2, 3, 5, 7, 9 12, 15, 18, 26 and the rest of the coil for a 12 position switch. These figures are only rough and a tune can usually be obtained on any band on several switch positions.

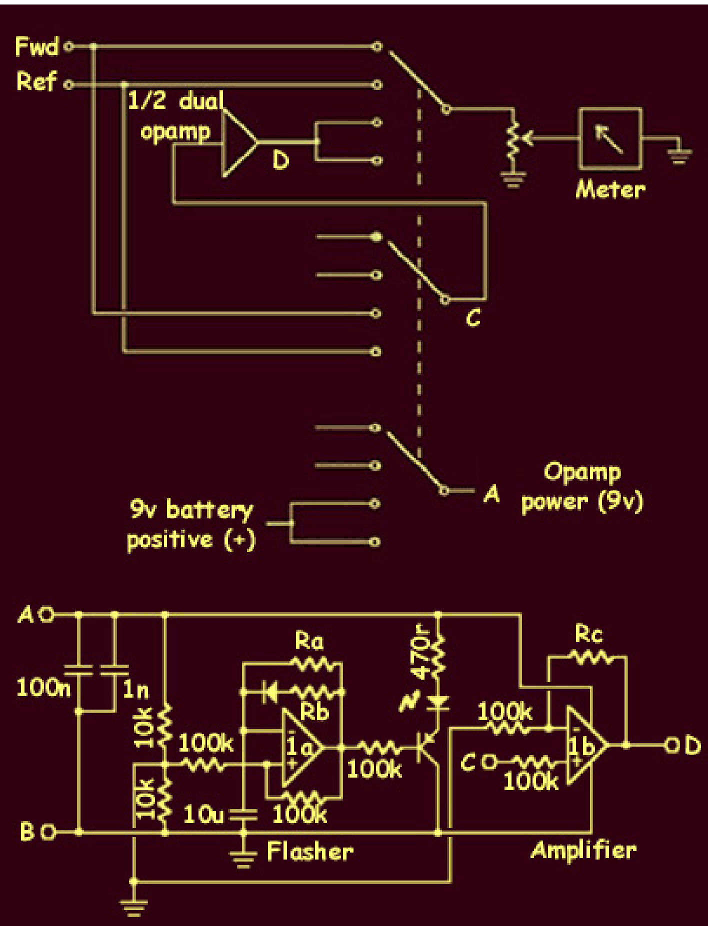
With feeder length adjustments, I now have a better than 1.2:1 tune on all bands from 160m to 2m including WARC. In fact, using the full coil, I can get a reasonable tune by ear to listen to the local AM radio stations in the high kilohertz.



NOTE: The electronics (op-amp) must be shielded from the rest of the tuner. The PCB panel between them achieves this. The output from the SWR pickups must also be RF bypassed on both sides of this shield.

SWR METER AND SWITCHING

At left are the wiring and circuit diagrams of



tuner MK2. A 3 pole 4 position switch selects either direct input from FWD and REF pickups or amplified signals from FWD and REF pickups. In the direct mode of operation (1st and 2nd positions) the battery is not used and switched out. In the 3rd and 4th positions the amplifier and battery are switched on.

The opamp can be any dual general purpose opamp. Some of the resistor values may have to be changed depending on the input impedance of the opamp used.

One half of the opamp (1a) is used to flash a LED every few seconds to indicate the unit is on. Ra and Rb can be used to select the duration and flash time of the LED.

The second section of the opamp (1b) is used to amplify the signals from the SWR pickups. It is simply connected as a non-inverting amplifier. Rc needs to be selected depending of the efficiency of the pickups and the power used.

Connection points between the switch wiring, battery and amplifier circuit are (A) switch to battery, (B) battery negative, (C) opamp input and (D) opamp output and are shown on both diagrams.

The inbuilt SWR meter is very handy and works better than the one in my radio. Both these meters read slightly differently no matter how long the patch cord or whether the linear amplifier is in circuit or not (between radio and tuner). If I tune up using the radio's SWR meter, the solid state linear trips the protection at about 1/2 power. If I tune up using the meter inbuilt into this unit, I can get full power out of the linear without drama.

COMPLETED UNIT

The front panel was made by printing the desired text and graphics on a printer. It was then laminated with a backing piece of paper so that the lamination would on be on one side of the front panel. This facilitates gluing the front panel onto the front of the unit using PVA woodworking glue. Because of the laminating material this takes quite some time to dry but will dry sufficiently over a few days.

The knobs were made by cutting out some sheet fibreglass with a hole saw then making and gluing the scale in the same manner as the front panel. This was then glued to some commercial knobs using epoxy. See downloads below for some graphics you can use for making such knobs all in one file.

The scale on the SWR meter was made in the same manner.

Graphics for the knobs can be downloaded here as .tif images (670kB), as .jpg images (412kB) or as both .tif and .jpg (1Mb)

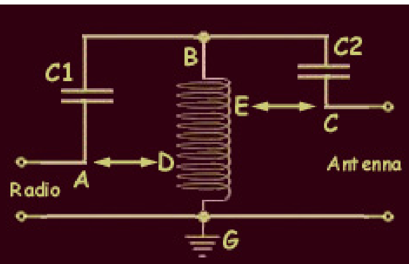
HOW IT WORKS

This description is not truly accurate and very brief. Perfect components have been assumed and both source and load impedance largely ignored. A full description involving all of these other things is too complicated for this page and the values outside of the tuner are not known anyway. IT IS ACCURATE only on basically how it actually works.

I have heard people describe a tuner as just a low pass filter. Since the impedance of a capacitor decreases with frequency and the impedance of an inductor increases, this just doesn't make sense. This T match should work better as a high pass filter. In fact, it isn't used as any sort of filter at all. It is used as an adjustable impedance matching auto-transformer.

For this example the frequency will be constant and can be anything. For a different frequency, component values change but the effects are the same.

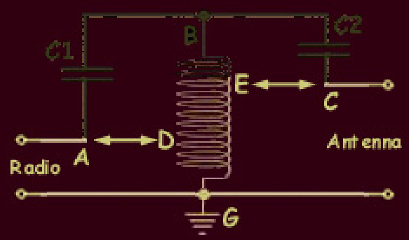
Suppose the coil has an inductive reactance of 500 ohms. Suppose also capacitor C1 is chosen so it has a capacitive reactance of 400 ohms. The current through the capacitor is 180 degrees out of phase with the inductor so the radio side of the tuner will see an inductive



reactance of 100 ohms. If the inductive reactance between D and G is also 100 ohms, points A and D will always be at the same potential.

That is to say, since A and D are always at the same potential, they are virtually connected.

Similarly for the antenna side of the tuner. Suppose C2 is chosen so that it has a capacitive reactance of 100 ohms. The same thing applies between E (chosen to be 400 ohms away from G) and C so the antenna side will see an inductive reactance of 400 ohms. E and C are virtually connected.



At some frequency where component values achieve the reactances as described above, we now end up the equivalent circuit shown at left (bright traces).

If it looks like and duck and quacks like a duck, its a duck. If it looks like an auto-transformer and acts like and auto-transformer, its an auto-transformer. In this case 1:4.

Extra notes:-

1) In the diagrams above, only the impedance has been considered, not the number of turns. The number of turns between G and D will be the same as between D and E. (Double the turns quadruple the reactance).
2) In this example, the voltage at point B (with respect to G) will be 2.2 times the input voltage (D to G). The voltage at point C will be double the voltage at point D.
3) This works just as well if C2 is removed and a direct connection made between E and C and with C1 left in place. Similarly for C1 and connection A to D with C2 left in place. It will also work just as well with both C1 and C2 removed and connections A to D and E to C made.
4) Because the load between C and G may be capacitive or inductive, the value of C2 could vary from this value to achieve the same 1:4 match. Likewise C1.

USING IT

Many tuners have a 4:1 balun included in them. This is a complete waste of time and energy because this tuner does all the impedance matching necessary. All that is required is a simple 1:1 current balun with sufficient turns. This will have a lower insertion loss than anything else. From there on this combination can be used to drive a dipole either centre or offset fed or a sky loop.

To tune a band:-

1) Set the capacitors half way then rotate the band switch until the maximum volume of noise or incoming signal is heard.
2) Adjust the two capacitors in turn until the same max volume of incoming noise is found.
3) Find a free frequency (by asking) and select a mode such as FM or AM (RTTY on some radios) where

a carrier will be emitted, and turn the power right down.

4) Select REV first on the SWR meter and, while emitting a carrier, fine tune the two capacitors in turn for minimum reading.

5) Calibrate the SWR meter on FWD then set to REV and take the final SWR reading with further fine tuning if needed.

6) If you really can't get a good tune (better than 1.2:1) then try moving the band switch up and down one position and repeating steps 2) – 5)

There is no antenna or band I have not been able to tune in a few seconds with a bit of practice. If you really can't get a good tune within 20 seconds, you have something wrong.

TOP OF PAGE

Experimental KW Switching Power Supply

Initial Design and Test Report - Dec 28, 2003

By W5JGV

This is an ongoing narrative of my attempt to construct a high-power switching power supply to replace the failed power supply in my Heath Warrior amplifier. Since I use the amplifier for experimental (non-Ham) work, it sometimes has to operate at full CW power for several hours at a time. The original plate transformer is unsuitable for that task, so I am attempting to build a really heavy-duty supply to replace the original power supply.

My design concept started when I inherited a large quantity of well-built Dell computer power supplies. They were rated for 230 watts, and some testing showed that the switching transformers in the supplies could easily handle 250 watts. Hmm... If there was just a way that I could make these things put out HV instead of +5 Volts, I'd be all set. Well, to work!

I started by reverse engineering the supplies, and soon had a rough schematic diagram sketched out. It was quite simple, really. When the supply operates on 120 Volts, half of a full wave bridge rectifier charges a pair of filter capacitors to + and - 150 Volts, respectively. These voltages are alternately switched across the primary winding of the power supply transformer by a pair of transistors connected in a "totem pole" configuration (A half-bridge" circuit.) The secondary windings produce various voltages which are rectified, filtered and distributed to the loads in the computer. Samples of the +5 and +12 volt output are used for feedback to the voltage regulator circuitry.

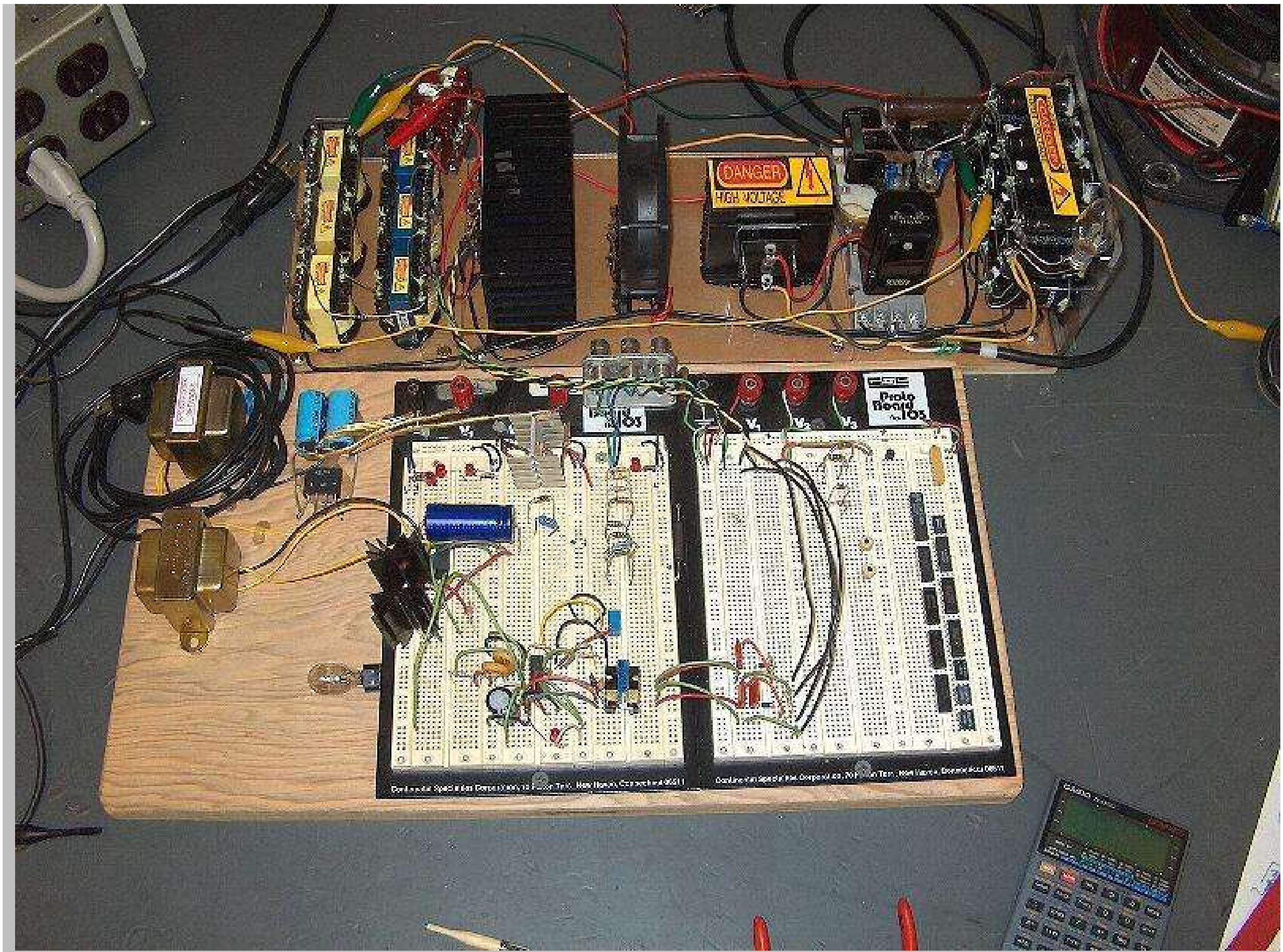
Unlike the series pass regulators most of us are familiar with, computer power supplies use a pulse-width modulation system to vary the output voltage. Another difference between computer power supplies and the "big iron" hams use if that these supplies use a switching frequency of something in the neighborhood of 25 KHz. This allows the use of a much smaller power transformer than if the operating frequency were 60 Hz. This means that a lot of watts can be pushed through a very small transformer. These particular power supplies use a Texas Instruments TL494 Pulse Width Modulator (PWM) IC (16 pin DIP). Identical substitutes are the Fairchild KA7500B and the NTE 1729.

Because of the high switching frequencies as compared to 60 Hz, it is necessary to use fast diodes for rectification. I used UF4007 diodes, obtained on eBay. These are the same as the venerable 1N4007 but a heck of a lot faster in recovery time.

Then power supplies were decomposed into a pile of useful parts. Some of the diodes were used, as were the main 150 Volt filter capacitors. Interestingly enough, the original power switching transistors, which originally handles 230 watts, were rated high enough to easily handle a full KW. Tests showed that they could, in fact, handle that power level. (Barring the authors' ham-handedness with clip leads - see the picture further down the page.) One fan was pressed into service to cool both the main power rectifier and the switching transistor heat sink. All of the 150 Volt filter caps from six of the computer power supplies were ganged together to make up the main filter cap bank. A time delay start circuit was added to handle inrush current surges. (A primary line noise & RF filter network will be used on the finished product.)

The switching transformer(s) deserve some mention here. The step up transformer is a actually a set of six computer power supply transformers, all having their primary windings connected in series. This becomes the high voltage secondary winding; it's just distributed across six transformers instead of one. The primary winding, which is connected to the switching power transistors, consists of the windings which were originally used to supply the +5 volts from the computer supplies. These windings are wound 5-0-5 volts for a full wave rectifier connection. I abandoned the center tap of the windings, and connect power across the entire winding. All six of the transformers have their 5-0-5 windings connected in series. The high voltage secondary winding is composed of the original primary windings, all of which are also connected in series. Although this works, there appear to be some voltage breakdown problems (All the Magis Smoke) escaped from one of the series-connected transformers during an overpower test) and it may be necessary to go to a single transformer instead of series-connected units. More on this later, as I figure it out.

OK, let's start with some pictures...



This is an overall view of the test setup. At the far upper right of the picture, you can see the 16 ampere Variac I use to help keep the smoke inside the components. At the far upper left of the picture you can see the outlet box on my 2.5 KVA isolation transformer, which helps keep the smoke inside of me and my test equipment. In the top center of the picture is the guts of the switcher system.

Starting from the left of the unit, you can see the set of six transformers which have been taken from the computer power supplies. The green paint on the connections indicates that I have visually and mechanically inspected the solder connections before applying power. To the right of the transformers is a black heat sink, salvaged from a Pentium-II processor. The power switching transistors are located on the back of the heat sink where the wires connect to the transistors. To the right of the P-II heat sink is a fan, also taken from one of the computer power supplies. It is powered by a 9 volt, 450 MA wall-wart purchased at the thrift store for 50 cents. After some experimentation, I found that a spacing of 1 inch from the heat sink gave the best cooling and the most even heat distribution across the heat sink. Closer or further spacing results in uneven cooling. The fan also sucks some air past the heat sink just to the right of the fan - the one with the "DANGER- HIGH VOLTAGE" label on it. That heat sink came from a cast-off Pentium PRO processor, and now does duty as the cooling device for the 30 amp bridge rectifier you can see bolted to the front of the heat sink. Regarding the bridge rectifier - I only use two legs of the bridge, and the current is low enough that I could have used one of the bridge rectifiers from one of the power supplies instead, but I had this one available.

To the right of the diode bridge is a black time delay relay mounted on a gray octal socket. This relay closes the NO contacts two seconds after application of primary AC power, and causes the 30 amp power relay (partially seen behind the TD relay) to close its NO contacts, shorting out the 20 Ohm 50 watt Ohmite power resistor seen standing up horizontally above the power relay. The Ohmite resistor is in series with the AC liner and acts as surge protection to allow the 300 volt filter cap bank charge up without popping the line fuses.

At the far right of the setup is the filter cap bank, consisting of 12 - 680 MFD 200 VDC electrolytic, salvaged from the computer power supplies. They are arranged as two sets of 6 caps, wired in series, to provide an equivalent value of 2040 MFD @ 400 VDC. (2 X 4080 MFD @ 200 VDC) A "visual bleeder" is provided in the form of a 4-watt light bulb connected across each half of the capacitor banks. The final version will have two bulbs in series across each side of the capacitor bank to reduce the chance of lamp failure. There's some serious energy stored in that setup - it takes close to 30 seconds for the lamps to go out after the power is shut off!

Looking at the white double breadboard in the lower part of the picture, if you draw a line horizontally across the breadboard just above the large blue electrolytic cap on the left breadboard, nothing above the cap is connected to the system. The small power transformer to the left - the one without a label - supplies power to a bridge rectifier and charged the big blue filter cap to ~30 VDC. This is regulated down to +17 VDC by an LM317 regulator which is mounted on the black finned heat sink seen at the far left of the white breadboard. The heat sink, of course, came from a computer power supply.

The assortment of parts seen at the lower middle of the left white breadboard composes the switching control circuit. The black IC - partly hidden by the thicket of wires - is a TL494 switching power supply controller. It came from - guess where - one of the computer power supplies. It's readily available from several suppliers, and costs under a buck. It consists of a sawtooth waveform generator followed by a J-K flip-flop driving a pair of output transistors that can handle 40 V @ 200 MA. A pair of DC level comparators connects to the innards of the ramp generator to vary the duty cycle of the output signal - which is a square wave, BTW - thus allowing the main switching transistors to conduct for however long is needed to provide the power required by the load. Of course, the designer has to provide the necessary feedback circuit to make this all work. (That's about 90% designed, and 0% tested!)

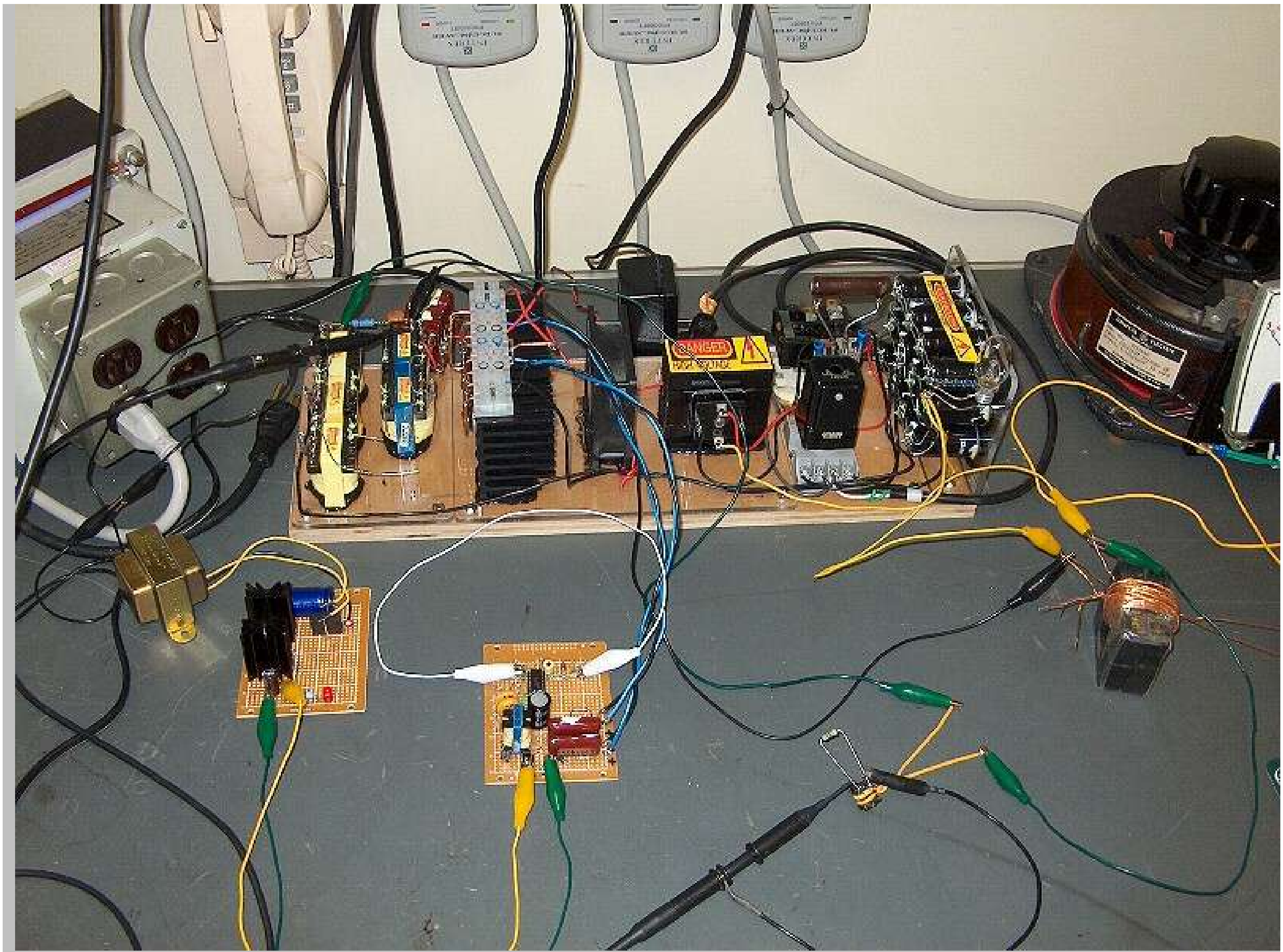
The few parts on the lower left of the right hand white breadboard are part of the base drive circuitry between the power transistors and the driver transformer, which is seen at the bottom right of the left hand white breadboard. Can you guess where the driver transformer came from? Right!!!

The voltage control feedback circuit will sample the +1500 volts at the output and send it to the TL494 comparator inputs. Over current sense will also be provided to shut down the supply in case of a HV load short or serious overload, such as an internal arc in a PA tube. At the bottom right of the picture is my best tool - my calculator. If the math says it will work, it will!

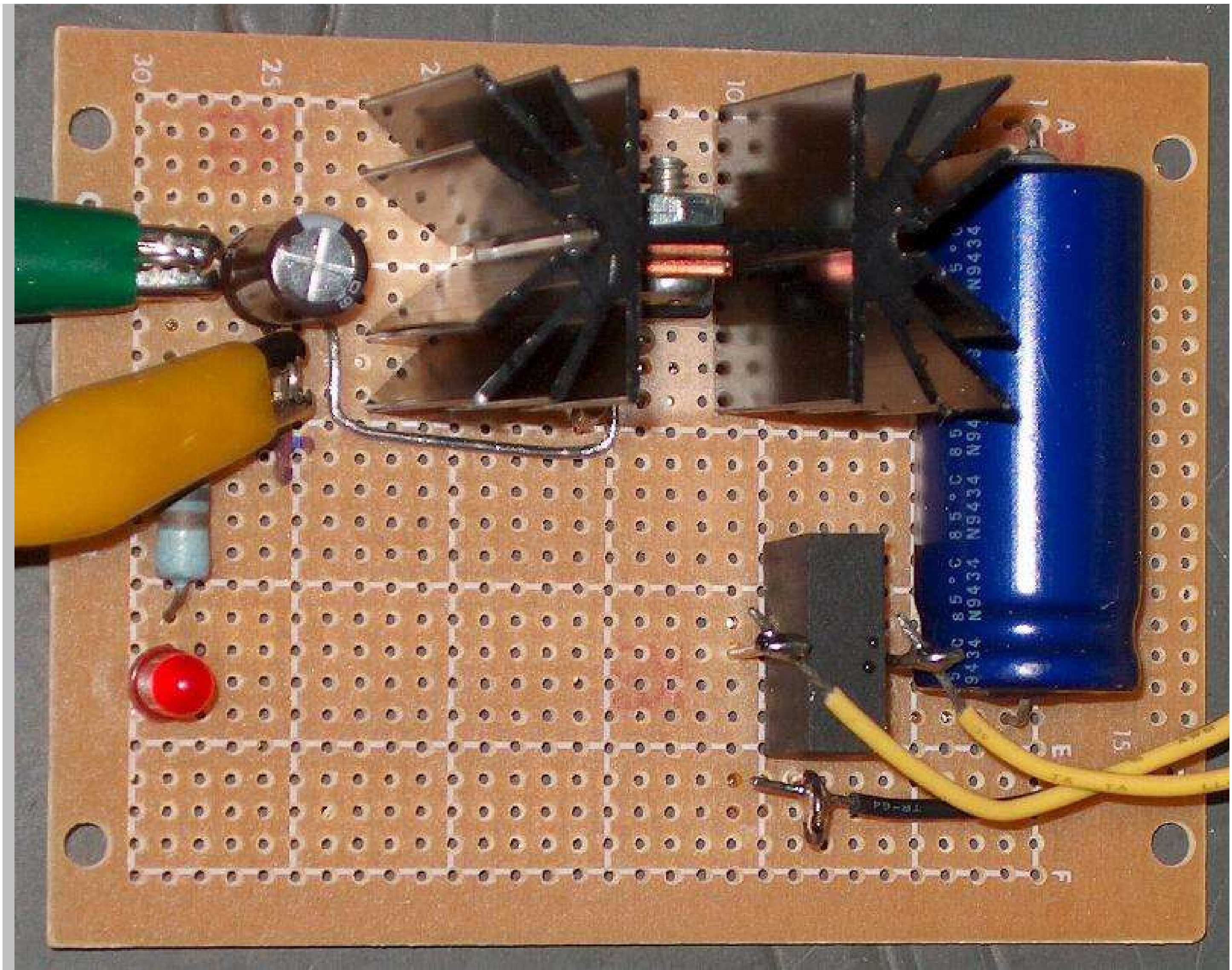
The smoke has seriously escaped from these power transistors! I was running the primary DC voltage at about 400 volts instead of 300 (to see what would happen - now I know!!) and I think I bumped the breadboard and accidentally hit something that caused both transistors to switch on at the same time. This picture also gives you a close up view of the jumper connections for the transformers. Like the warning labels? I scanned one (from a computer supply, of course) and printed a few of them out and stuck 'em on the various parts.

Ahh! That's much better! After replacing the switching transistors, I installed a nice heavy-duty terminal strip to make connections easy and positive for testing. The heavy copper wires help keep the transistor leads cool and are easy to unsolder and bend away slightly if it becomes necessary to replace the transistors (again!) Note the cut-off bare wire from the transformer in the lower left of the picture. it went to the transformer that smoked while testing at high power. The transformer has been removed and dissected to determine the cause of failure.

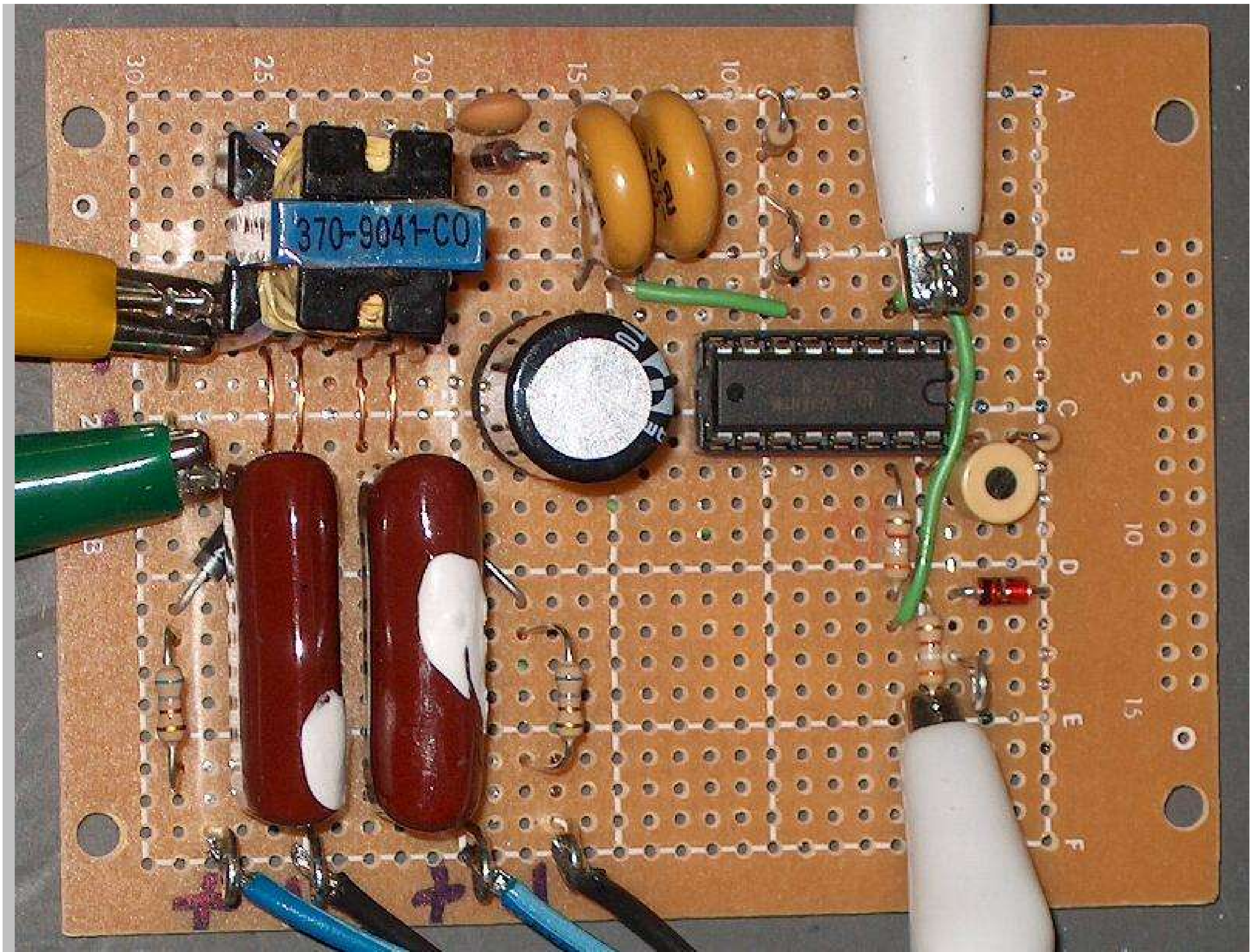
A close-up view of the main filter capacitor bank. It consists of 12 caps, each rated at 680 MFD @ 200 VDC. They are arranged as a two sets of six of these caps in parallel, with both sets in series. The series set is then charged to +/- 150 VDC through half of a 30 Ampere 600 Volt bridge rectifier directly from the power line. The brown Ohmite power resistor is the inrush current limit resistor. The small "night light" lamp is a self-indicating bleeder resistor. There is one across each set of filter capacitors. The final version of the supply will have two of these lamps in series across each set of capacitors for higher reliability.



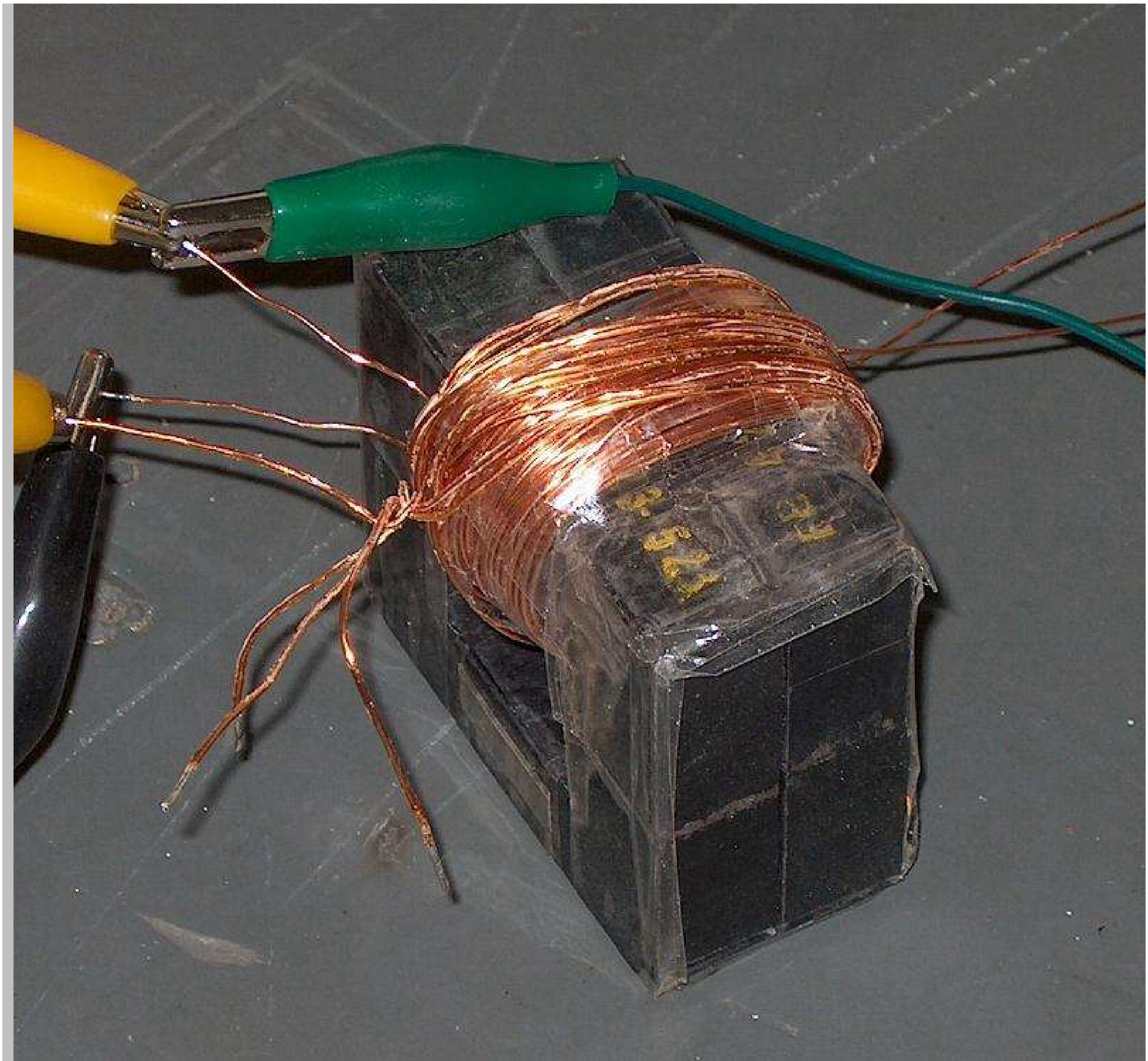
The breadboard setup after the +17 Volt power supply and the Switcher Driver circuits had been finalized and assembled on perf boards. note the missing transformer from the main prototype setup. At this point, all six of the switcher transformers are out of the circuit and have been replaced by the single hand-wound prototype transformer visible at the far right of the picture. The scope probe is connected to a current sample transformer that generates a signal proportional to the current from the main switching transistors to the transformer. This will eventually be used to perform an instant shutdown of the system in the event of a serious overload.



The completed +17 volt power supply. A 24 VAC @ 450 MA transformer (yellow leads) drives a bridge rectifier (black rectangle) and charged the big blue filter cap to about +30 VDC. An LM317T regulator mounted on the finned heat sink, produces +17 Volts @ 300 MA for the switcher control board. An LED provided a visual indication that the supply is working. I used a fixed resistance voltage divider to set the output of the regulator, so, no adjustment is supplied. It either works right or it's dead!



This is the completed switcher control board. The IC is the TL454. The large yellow disk caps and the two resistors adjacent to them provide frequency control, in this case, 50 KHz. (The IC divides by two, so the actual square wave output is at 25 KHz.) The output stage of the IC drives the small transformer (370-9041-CO) and was used in one of the computer power supplies to drive the main switcher transformers. I decided not to reinvent the wheel, so to speak, and swiped the circuit for use here. The two large brown capacitors are 2 MFD each, and along with the diodes (partially hidden under the caps) and the two resistors, form the base drive matching circuits needed to connect the transformer secondary windings to the bases of the main switching transistors. The black and blue wires connect to the switching transistors. The green and yellow clip leads provide the +17 Volts to the board. The two white clip leads are for regulation feedback, and are not functional in the present setup. The small beige potentiometer and the adjacent components are the voltage feedback adjustment network.



A quick-and-dirty lash-up of a homebrew switching transformer. I used a pair of ferrite cores from a couple of large LOPT (horizontal output transformers) stacked side by side and scramble wound what I calculated was the right number of turns on the core. Insulation is a few wraps of Cellophane tape! Certainly not recommended for long-term use, but good enough for a quick test. Each core measures about 0.5 x 0.4 inches thick. The exact core material is unknown, but since these transformers originally operated in the same frequency range as I am using, I thought they would probably work well enough for testing. They did.

The last picture! The prototype supply driving the incandescent lamp load. There are a total of 10 - 100 watt lamps brightly illuminated - you do the math. Note that all that power is coming through the home-brew junk-box transformer I wound. The switching waveforms are visible on the oscilloscope, if a bit hard to make out. The lower waveform is the switching transformer primary current, and the upper waveform is the load voltage. It's AC, since the HV rectifiers have not been installed yet. Switching frequency is 25 KHZ, and the duty cycle is about 98%.

I'll post more info as I get things figured out.

73,

Ralph W5JGV

[Home]

ON6MU

QRP Magnetic longwire balun with VHF-splitter

RE-ABU3HF/S

By Guy, de ON6MU

About the MLB (magnetic longwire balun RE-ABU3HF/S)

This Magnetic Longwire Balun (MLB) makes it possible to efficiently use a coaxial lead-in cable with all forms of longwires, T-forms or other types of wire antennas, without the need for an antenna tuner. A very low loss magnetic transfer of energy from the antenna to the receiver is accomplished and static noise is reduced. Your coax is much less susceptible to interference. You can even connect a dipole to it.
It works fine with a heavy duty 41 foot (12.5 meters) wire, some nylon rope and a quality insulator. At the feed-line end the antenna is terminated with the Magnetic Longwire Balun. This balun permits an exceptionally low loss transference of antenna energy to your coax feed line. The result is significantly reduced static noise on long, medium wave and the shortwave bands.

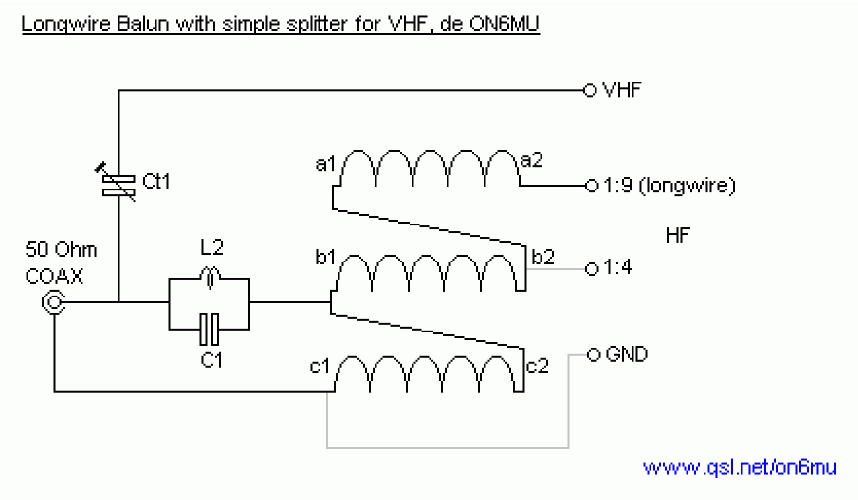
You do not have to Earth/Ground the Green wire sticking out of the top, but it helps minimize interference if you do. Grounding the balun / coax (pin c1) to a good earth made between 3 and 6 dB improvement on noise and QRM, even though the station was well-grounded.

You could add a shoke inside (or outside) the balun housing to prevent even more from coax radiating too. A few feritte beads over the coax or turn a piece of 50 coax a few time around a feritte core. If possible inclose the shoke inside the balun housing or as close as possible to the SO239 connector.
Long-wire antennas are directional, so bend yours to allow both N-S and E-W orientation. Height is dependent on your location and surrounds … experiment!!

you can add an extra output as described in the schematic if needed (1:4)

L2,C1 blocks VHF signals from entering the balun. Ct1 tunes the VHF antenna and limits the lower frequencies from entering the VHF rod. You can calibrate Ct1 by soldering 1 watt 50 Ohm carbon resistor (or dummy load) between Ct1 (VHF pin) and the ground of the connector. Use a low power setting (0.5 watt) and tune Ct1 to 1:1 SWR.

Schematic QRP Longwire balun with VHF-splitter



Parts list

-  toroid, feritte core of 15mm, or small Amidon red ring core, FT50-43 or T50-7 or for higher power: or Philips 4C6 or 4C65 (pink color), Amidon T130-2 red or T200-2 red
- 3 pieces of insulated wire (CuI) of 0,8mm
- CT1=5...30pF capacitor trimmer (green)
- C1 = 10pF
- L2=0,8mm CuI, 4,5 turns, 5mm diameter
- 2 x 25mm 3mm diameter weater resistant bolts (innox etc...)
- "banana" type plug for VHF antenna (no ground needed)
- SO239 connector
- electrical junktion box (painted after)

Specifications

- Peak Frequency range: 100kc...30Mc (mostly depending on the core) and 144...146Mc
- Max. RF power CW: 5...10W (also depending on the mismatch of the antenna and the transmission intervals)
- Max. RF power SSB: 10...15W (also depending on the mismatch of the antenna and the transmission intervals)
- Output impedance to 50 Ohms coax
- 1:9 output for longwire
- 1:4 experimental
- Rod VHF 1/4 (or 3/4) wave electrical length for 144...146Mc

Another related project: Magnetic Longwire Balun (MLB) also usable for dipoles

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ON6MU
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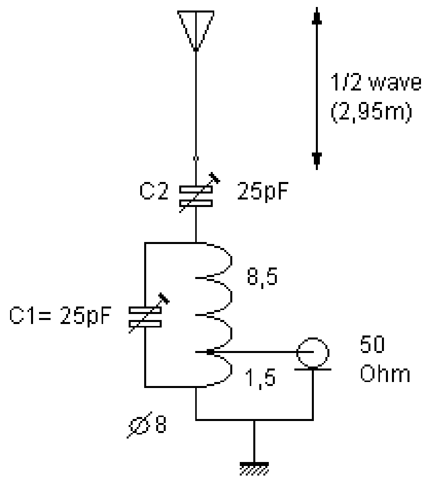
ON6MU

VHF 1/2wave vertical antenna for the 6-meterband (50 Mhz)
RE-A50V12

By Guy, de ON6MU

Schematic fig1



1/2 wave antenna principle

A much better type of antenna then a simple quatre wave and that has more gain is the 1/2 wavelength vertical. We know that the impedance of the 1/2 dipole is 70 Ohms when we attach the coax in the middle, but what if we were to attach our coax directly to the end? The impedance at this point is high, very high, so we must make a matching device to match the antennas impedance to the 50 Ohm coax. What would happen if we did not use this matching device? Well...you would know that this would result in a very very high SWR.
The bandwidth of these antennas are good, they can easily span the entire 50Mc band and more with a low SWR. But, in this design, the bandwidth is limited to approx. 600kc (without re-tuning C1 or C2). This allows you to tweak the antenna to your desired band and avoid interference and reduce intermodulation.
The antenna and ground are connected across the tuned circuit while a 50-ohm coaxial cable is connected to taps on the inductor. The tuned circuit presents a high impedance to the antenna and the tapped inductor steps this impedance down to 50 ohms. Adjusting the tuning capacitor tunes out slight reactance variation if the antenna is not an exact electrical half-wavelength.

Parts list

- 4 pieces of 1 meter alu or copper tubing:
  - one 18 mm diameter
  - one 15 mm diameter
  - one 12 mm diameter
  - one 10 or 8 mm diameter
- 1 female PL 259 chassis
- some cul wire (isolated wire like from a transformer etc.) of 0,8 mm thick
- a coil holder of 8 mm diameter
- two 25pF regulable capacitors
- A robust PVC box of approx 30x50x18 mm and 2mm or more thick
- a piece of hard insulating material that snuggly fits inside the base tube, like:
  fyberglass, nylon, hard pvc, hard wood, bamboo etc... as long as it's very strong, stress and weather resistant.
- and a few innox hose clamps

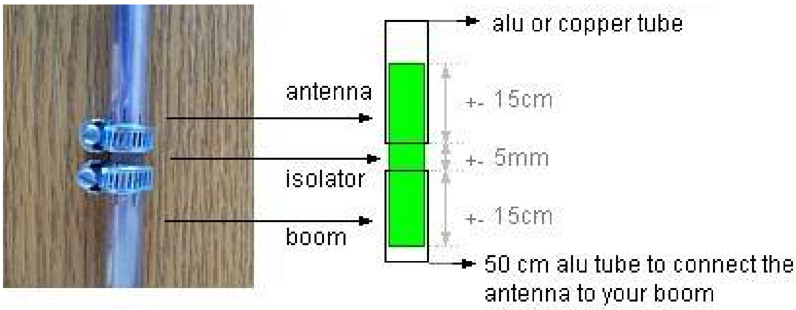
Note: there are many ways to build your antenna and I'm sure some can come up with better mechanical designs then described here although the design and material used here is cheap and easy to find. Also, the diameters of the tubing described here is not too critical.

Links of interest:

The antenna

- Construction:
The vertical itself is constructed out of four overlapping sections of aluminum tube whose sizes are given.

  - saw the 1 meter 18 mm alu tube in half. One part (50 cm) will be used as a boom and the other as the first part (also 50cm) of the antenna.
  - saw some grooves (approx 1,5 cm) in both halves of the tube to allow a hose clamp to tighten everything up.
  - same goes for the other tubes that fits inside eachother. All tubes are firmly fixed together by using hose clamps.
  - Measure from the base up 2,95 meters. You can alwyas tune the antenna to its best SWR by sliding the top tube in or out.



  - saw a piece of that hard insulating material of your choice and fit it 10 cm in the antenna and boom part and leave a gap of 3 mm between them.
  - hammer down one end of each of the 3 radials (3 x 22 cm) so it becomes a bit flatten. This will make things easier to screw tight with the hose clamp. These radials are fitted on the boom section.

- The little black box:

Here is where all the secrets are stored HI. I used a little plastic box where I placed the LC-circuit and the PL connector.
I also drilled two little holes where you can regulate the two capacitors with an little isolated screwdriver. Afterwards you can seal the holes up to prevent moisture from entering the box.

- The LC tank-circuit:
- Wind 10 turns of 0,8mm cul wire around the 8mm coil holder and make a tap at 1,5 turns. There is no spacing between the windings.
- The smallest part (the "cold side" 1,5 turns) of the coil is where your centre part of the connecor/coax is connected to. The above schematic shows how.

- As you can see there are two wires comming out of the box (which contains the LC): one for the antenna and the other for the ground (being the connecting boom piece).

- Connect the wires accordingly and be sure to seal everything up.

- Tuning:
- Get your old (t)rusty SWR-meter and and some 50 Ohms coax and connect your transceiver to it.
- Set the two capacitors to halfway to start with.
- Mount your antenna temporary 1,5 meters from the ground for the first tests and measure the antenna length (the boom piece NOT included) at 2,95 meters and try to ground the boom.
- Find a CLEAR frequency and set your transceiver to MINIMUM possible power and use a carrier type modulation (CW, AM, FM).
- Tune C1, which is the most important and critical capacitor, till the SWR gets a s low as possible on your desired centre frequency (51 Mc)
- Then tune C2 till the SWR is even more lowered or even 1:1.
- Repeat the last two steps at location if needed
- Fine tuning your antenna can be done by sliding the tubes in or out. Sometimes when your place your antenna higher or when the antenna has obstacles in its proximity the SWR can vary from the one you noted first. Raising or lowering the length of the antenna should fix it.

Highlighted

Specifications ON6MU Vertical Antenna RE-A50V12

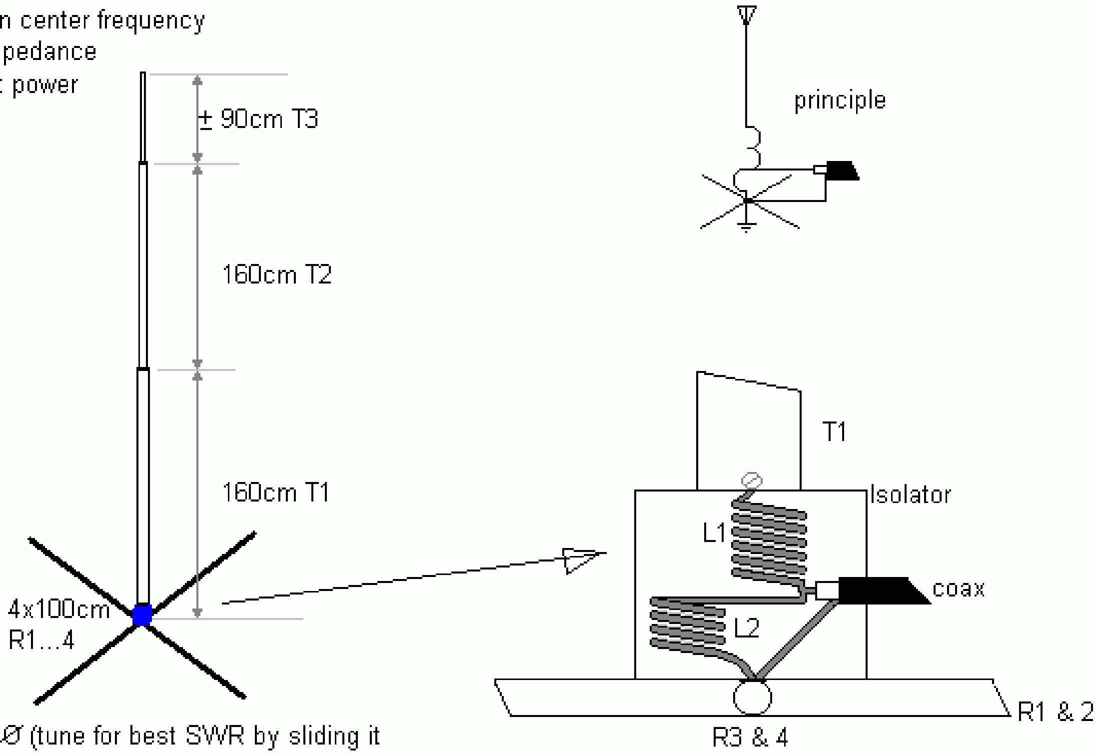
- Total length (including the 50cm mounting boom piece): 3,5m (2,95m effective)
- centre frequency: 51 Mhz
- bandwidth: 2 Mhz
- maximum tunable frequency range: 49...53 MHz+-
- impedance: 50 Ohms
- Gain: 3,6 dBi
- Maximum power using the components described: 20 watt
- NO counterpoise or radials needed if the boom is grounded or the boom length is >= 1,5m
- DC grounded (no static buildup)
- Height: 2,95m
- If needed, it can be disassembled into a very small bundle no longer than the longest element.

Be sure to seal everything up to avoid moisture, corrosion etc...

5/8 vertical groundplane antenna for 50MHz RE-A50V58

5/8 vertical groundplane antenna for 50 MHz,

Omnidirectional pattern
4.7dBi gain
2 MHz Bandwidth at 1.5 SWR
1:1 SWR on center frequency
50 OHm impedance
200 W max power



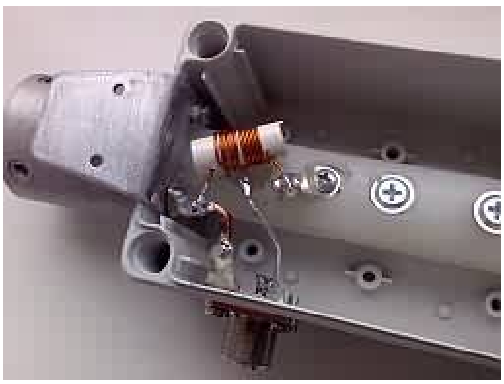
T3 = 10mm Ø (tune for best SWR by sliding it in or out T2)
T2 = 15mm Ø
T3 = 20mm Ø
R1...4= four tubes of 1 meter or 2 tubes of 2 meter crossed Ø 8mm or Ø 10mm
All alu tubing

L1 = 7 t 0.8mm, coil Ø 10mm
L2 = 5 t 0.8mm, coil Ø 10mm

de ON6MU

Note: If using a grounded boom, you can leave out the radials R1...R4 or shorten them to approx. 4x30cm

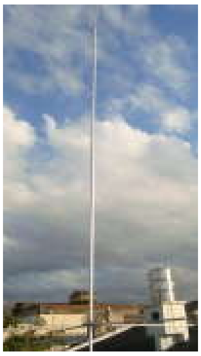
This is how Greg, **SP5LGN** constructed my 5/8 lambda 6-meter GP antenna:



Click to enlarge
Many thanks Greg!

How Horacio LU9DFN made it:

Click to enlarge
Many thanks Horacio!

SWR:
You can fine-tune the SWR to peak in the bandsection you are planning to use the 5/8 groundplane antenna by:

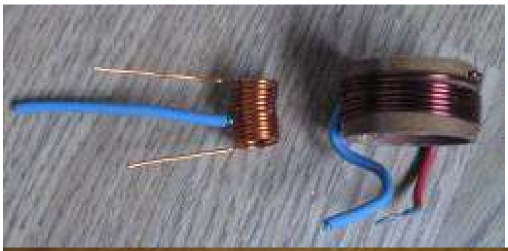
- - shorten or lengten the radiating element (vertical section)
- - shorten the radials
- - experiment with the coil spacing

Today's specials:

ON6MU Homebrew projects
Radioamateur related projects

ON6MU Ham mods
Modifications of transceivers

PA3BEN sent me a lot of pics on how to convert an old CB antenna using my schematic (shown here above) for 50Mc! I've put here 2 resized pics (do to lack of webspace, sorry):



Thanks Ben!

Please take a look at my 50mc wide-spaced yagi antenna

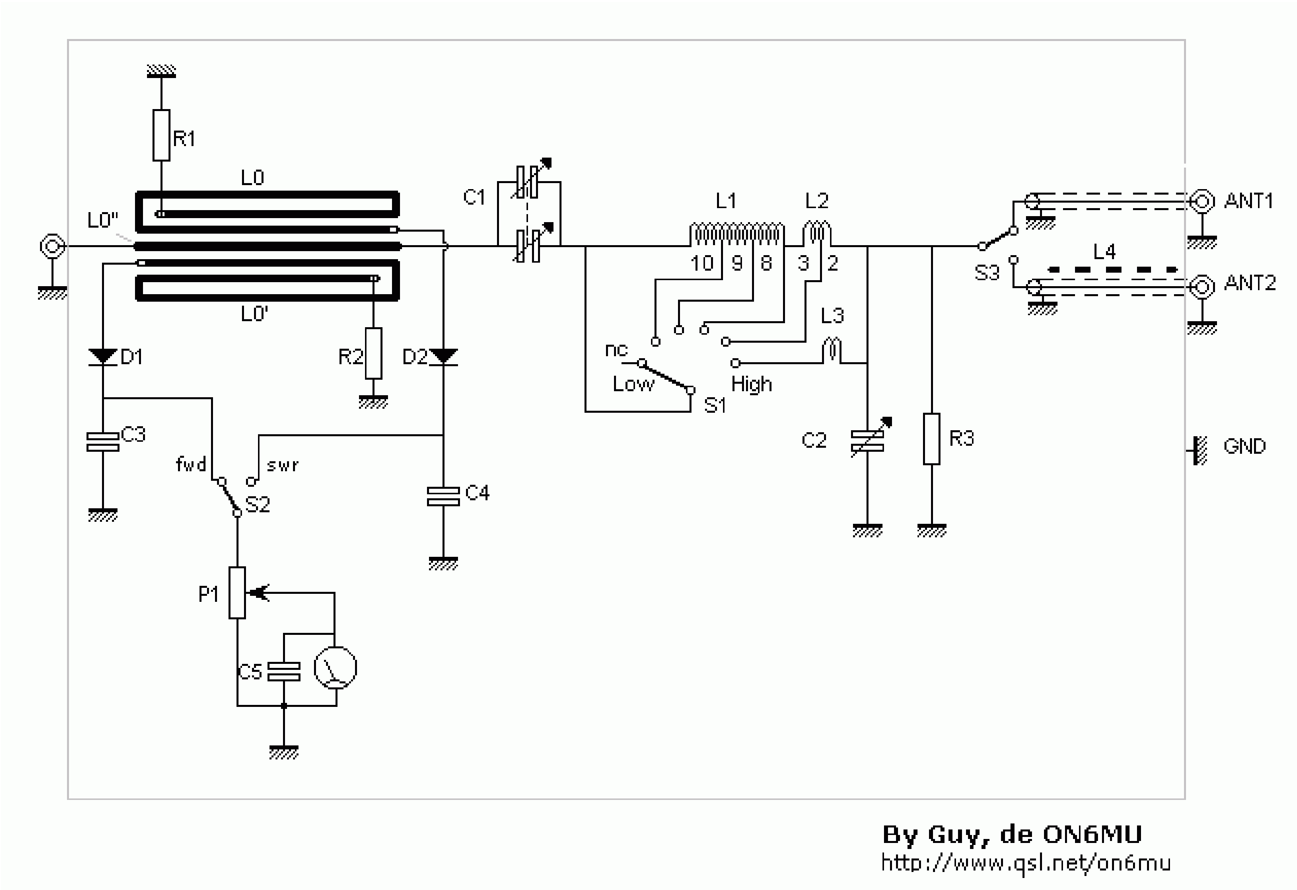
ON6MU

HF/6M Antenna Tuner Preselector and Antenna Switcher RE-AT1HF6

By Guy, de ON6MU

revision 3

RE-AT1HF6 Schematic fig1



Parts list

- alu box of 200mm X 130mm X 70mm
- 3 female PL 259 chassis

- Analog Meter (as sensitive as possible and calibrate the scale with a good SWR meter)
- C1 = variable capacitor of +/- 2 x 500 pF (air spaced)(1kv). C1 isisolated from the ground!
- C2 = variable capacitor +/- 280pF (air spaced)
- S1 = 6 pos. switch
- S2 = mini toggle switch
- S3 = solid 380v/10A toggle switch
- P1 = 10k log variable resistor
- D1, D2 = 2 germanium diodes AA15,AA109 etc.
- R1, R2 = 50 Ohm (2 x 1/4watt 100 Ohm parallel)
- R3 = 4k7 1watt carbon (or non-inductive resistor)
- C3,C4 = 4n7
- C5 = 22nF
- L1 = 1,5mm insulated copper wire, 27 turns close together, 19mm outside diameter (16mm inside)
  taps at 10, 9 and 8
- L2 = 1,5mm insulated copper wire, 5 turns with 1mm space, 19mm outside diameter (16mm inside)
  tap at turn 3
- L3 = 1 mm insulated copper wire, 4 turns no space, 9mm outside diameter (7mm inside)
- L4 = RG-58 coax wound around a 8 cm long carbon rode and fixed with tape
- L0 & L0' = 1,5 turns approx. 6 cm as long as the centre part L0" which is 1 mm separated.
  you also can use self-adhesive copper tape instead of wire or a toriod.
- L0" = 6 cm long copper wire (or copper line of 5 mm wide if you use a PCB)
  (L0, L0' and L0" makes out the SWR meter which is laid out as in the schematic fig1)

Specifications

- long wave, medium wave and shortwave preselector tuner lets you boost your favorite stations while rejecting images, intermod and other phantom signals on your shortwave receiver.
- frequency range: 2Mc...52Mc
  180m band depending on the mismatch of the antenna used and/or maximum inductance.
  Experimenting with the coils can be desirable.
- 150 Watt +-
- switchable between two antenna's
- shoke antenna output

- band-pass type (harmonic filter)
- pre-selector
- SWR meter (if needed, else you can simply leave it out HI)

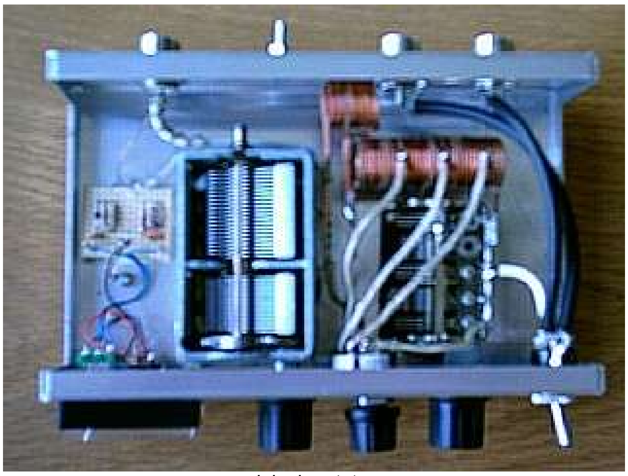
Revision 2 notes:

- improved SWR bridge
- R3: to drain any possible static build-up on your antenna

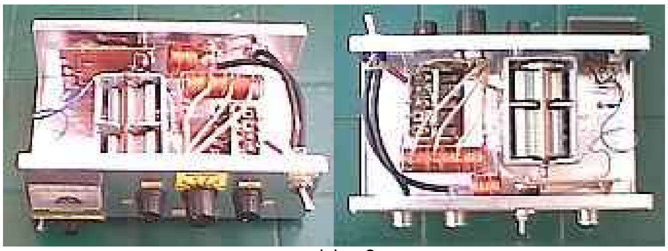
Revision 3 notes:

- L3 added and last of L1 tap changed to allow tuning up to 52MHz!
- L1 changed (was at 9, 9, 9 and 4) for better bandspread and higher top frequency range
  L2 (was 1mm, 10 turns close together, 18mm outside diameter) removed in revision 3 (click on the link for revision 2).
- Choke antenna output added to prevent HF-currents on the transmission cables (to improve immunity when using badly tuned antenna's)
  Can be used on good antenna's too of course.
- Notes: remember that you can always experiment with inductance (L1, L2, L3) to best suit your specific needs.

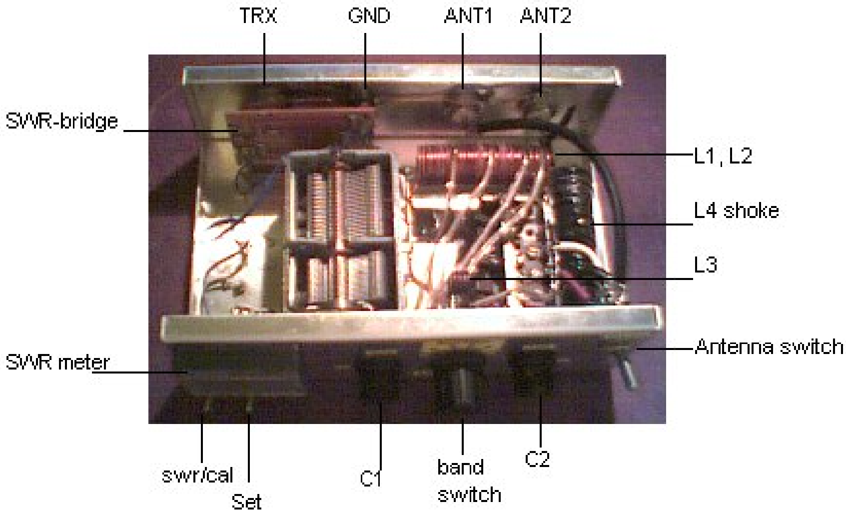
Pictures



original prototype



revision 2




All revisions

This is how **Herman PA3EHZ** made the tuner:


click images to enlarge
Thanks Herman for the pics!

If you elect to use an antenna tuner, it is extremely important that you understand exactly how to use tuners and what they can and cannot do. A few watts of RF can easily become lost in an incorrectly adjusted antenna matching device. I cannot overemphasize the priority of a clean, efficient connection of the amplifier output to a resonant antenna.

Don't forget to check these out:

ON6MU Homebrew projects
Radioamateur related projects

ON6MU Ham mods
Modifications of transceivers

73"

Home

13,8v/5Amp 78H05 based power supply for portable use: RE-PSF14A5

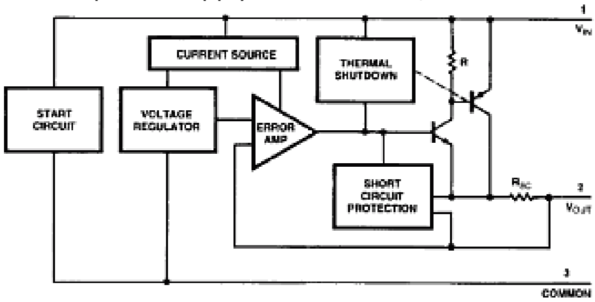
FT-817

By Guy, de ON6MU

I wanted a compact but powerful and versatile power supply to take along when I go on vacation, camping etc.
I use this power supply for a Yaesu FT-817ND and similar (QRP) transceivers. This transceiver uses 2 amps at full 5 watt TX and so the power supply has a large enough margin to let the build-in battery cells to charge and let your FT-817 work at full power and still have power to spare. Still, this power supply is compact enough to be used for portable use and the FT-817 fits perfectly on it HI. Ok, the power supply could be made smaller, but I needed 5 amps to use with my power hungry TM-255 @ 5 TX watt power.

The 78H05 can easily manage 5 amps at constant full load, has thermal overload protection, short-circuit protection and safe area protection! If the safe operating area exceeds, the device shuts down rather then failing and damaging your expensive transceiver/equipment!

If you do not need 5 amps you can always use lesser diode bridge and transfo amps which allows you to reduce the size of the power supply. The FT817 and simular QRP transceivers often don't need more then 2 to 3 amps anyway.
An ideal power supply for SWL's too, like for FRG-100 and so many others.



Remember to isolate the 78H05 and the 7805 from the chassis! This is very important! Also use thermal cooling paste/grease and a conservative but efficient heat sink.

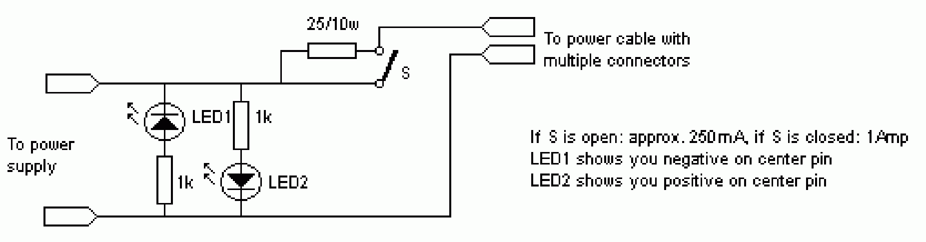
The zenerdiode is a 5watt (1,3 watt should be sufficient too) 8,2 volt type and the extra diode in series gives you an extra 0,6 volt which gives you exactly 13,8 volts (5volt + 8,2volt + 0,6volt). Most transceivers can work with lower voltages, so if you want you can leave out the diode and so giving you an output voltage of 13,2 volt.
S1 is used to switch and monitor between the two voltage regulaters output. Calibrate the meter by using the 4k7 pot.

For personal use I included a little 1 amp circuit along with it to be used for other equipment (or batteries etc.) when I'm at /A or /P. Switching S2 and S3 can obtain you 4 different voltages depending on the two zenerdiodes zd1 and zd2. This saved me carry space because I do not need to take along other power supplies for my little radio, portables etc. For this reason I made a charger interface (or you can choose to build it in) and a cable with 6 different types of connectors (also a 9 volt clip). You can change zd1 & zd2 to whatever voltages you might need on your /A adventure. The connector is been fed through a 25 Ohm 10 watt resistor which can be switched on and off to be used as a simple current reducer for battery charging. I mounted the resistor agains the metal chassis of the switch which helps to cool it down a little if using 12 (or more) volts via the 78M05 (1AMP).

The second way (instead of switching between fixed voltages) is a schematic that uses the 7805 to continues regulate the output voltage bewteen 5 to 14 volts. You may choose whatever principle you have the best use for in your power supply.

The multi-functional power connector

And the little schematic:

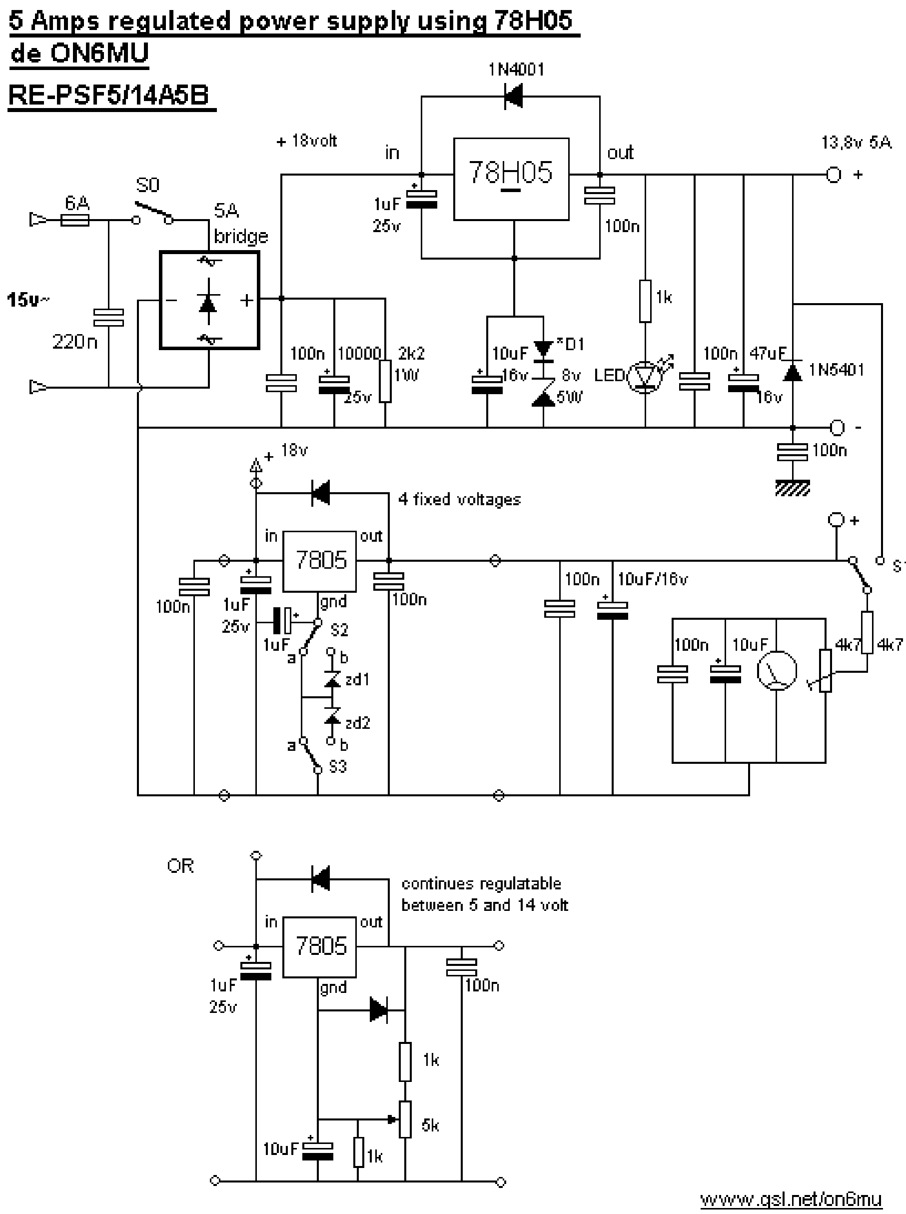


As some devices uses reverse polarity (negative on the center pin) I placed two LED's to show you which polarity is used.

Zd1=2,4v/Zd2=4,3v

S2	S3	V
a	a	5
b	a	7,4
a	b	9,3v
b	b	12

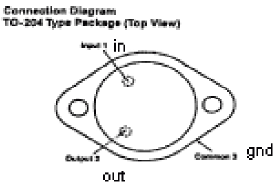
RE-PSF14A5 Schematic



The power supply insides

Dimensions:

Alu box: 132x55x128



78H05

Technical specs:

Description = Fixed Positive Voltage Regulator
Output Voltage Nominal (V) = 5.0
Load Current Max. (A) = 5.0 - 6.0 peak
Load regulation = 0.2% V-Out
Tolerance (%) = 1.0
Drop-Out Volt Max. = 2.5
P(D) Max.(W) Power Dissipation = 50.0
Supply Voltage Maximum (V) = 30.0
Temperature = -55C° to 150C°
Package = TO-3
Pins = 3
Military = N

More of my projects:

12-20amps power supply

The power supply in my quick-take-along-emergency-ft817-carry-case (what a name!)

[FT817]

[Home]
www.qsl.net/on6mu

ON6MU

"MUrDuck" VHF "rubber duck" Portable Antenna

RE-A144V1P

de ON6MU

You can make your own 2-meter "rubber duckies" that will likely perform much better than many commercial units. I compared my design with two other "rubber duckies" of the TH215 and ICT7 which outperformed them both. With the "duckie" of the ICT7e as much as 10dB. It does not has a gain compared to a 1/4wave antenna ofcourse, but compared to most standard "rubber duckies" its average "gain" is about 6dB (or more). This has several reasons:

- You can tune it for optimal SWR/performance and to the centre frequency you desire (factory duckies are mass-produced and their SWR isn't always good. The TH215 antenna had an SWR of 1:1,4 and the ICT7 dualband antenna was 1:1,6 SWR)
- The coil is much much better and has a higher Q (less loss)
- The effective antenna length is 24 cm (about 10 inches = 1/8wave)
- Performs much better and cost way less then a commercial one!
- Can handle more power (isn't that important for HT's, but nevertheless...an advantage.)
- Better radiation pattern
- You can build a replacement antenna that delivers a lower SWR and more RF output than the one that came with your radio, and you can do it for 10euro or less and a couple of hours of fun! And...It's educational, it's HAM-radio and what's more fun then using your own homemade antenna and to see it out-perform most commercial "duckies" HI.

This design is based on using a maximum applied RF power of 15 W at 144 to 148 MHz.

<u>To test and tune you need:</u>

- A accurate SWR/Power meter and field strength meter
- A HT or low power transceiver and some coax with the proper connectors

BNC

Half finished

TH215 duckie

Results in practice, tested at five different positions:

Position	ICT7e ant (10cm)	MUrDuck 1/8 wave	Kenwood 1/4 telescopic ant
A	S 4	S 9+	S 9+6dB
B	S 7	S 9+12dB	S 9+15dB
C	S 3	S 8	S 9
D	S 5	S 8	S 9
E	S 9+6dB	S 9+20dB	S 9+30dB

Transmitter: Icom ICT7e @ 0,5 watt
Location: City, inside building, 1Km

Receiver: Kenwood TM255
Location: City, 2x5/8 comet @ 18mASL

Conclusion: Our "MUrDuck 1/8 wave duckie" performs much better then the standard Icom ICT7e dualband duckie but does not beat a the quarter wave Kenwood dualband telescopic antenna. Although the results between the quarter wave and the "MUrDuck" are very close, the measurements between the factory ICT7e duck-antenna are quite impressive!
Note: the S-readings are not calibrated readings!!!

What you need to build the MUrDuck (RE-A144V1P):

- some copper electrical installation wire of 1mm diameter
- some "left-over" 3cm 5/8" PVC pipe
- a piece conducting material of 25cm in length,
  like: thick flexible electrical installation wire, RG58, Aircell+, 5mm(or more)earthwire,...
- a male BNC-connector (I used a BNC to Cinch connector)

Wind 5 turns of 1mm wire around a coil form of 10mm diameter, keeping the turns about 0.5mm apart. This will fit snugly into the 5/8" PVC tube.

The is coax soldered to the coil and the coil is soldered to the centre pin of the BNC. Solder it to the coax (if you use a coax as antenna): The center conductor and the shield of bothe sides of the coax is connected together. Cut if needed (optimal SWR). Mine was cut to 24 cm.

To Test

For optimal performance, use a VHF SWR/power meter and a field-strength meter to tune the antenna. If you don’t, your
homemade antenna may still work at least as well as the factory antenna. I used a Daiwa SWR meter and a "homebrewed" field-strength meter positioned about eight feet away from the transceiver. Connect your new antenna to the SWR/power meter using the proper combination of connectors.

(A right-angle SO-239 adapter and a PL-259-to-female BNC adapter worked for me.) 

Attach the radio’s antenna output to the SWR meter’s transmitter input with a 60cm (or shorter) length of coaxial cable.
Adjust the field-strength meter’s location and its antenna for a mid-scale reading.
Connect your commercial rubber ducky to the SWR/power meter and check the antenna’s performance; log your measurements.
Those are the numbers you’re going to beat. We’re looking for minimum SWR, maximum power and maximum field strength.

Now, attach your homemade antenna to the SWR meter. Check the antenna’s SWR and field strength. Gently adjust the
vertical position of the whip until there is an improvement in the readings if needed. Try squeezing the coil turns closer to each other which influences the SWR too. Continue making adjustments until the readings are optimized.

Once you are satisfied, run a bead of glue around the base of the whip. Place
the 3cm 5/8" PVC pipe over the coil, overlapping both ends of the coil form and leaving enough space to push in the BNC connector and room to fill the rest up with glue of a glue-gun.

You can see the BNC-connector which is pushed in the PVC-pipe by carefully heating up the end of the 3 cm long PVC 5/8" tube. After checking the SWR it's filled with glue from a glue-gun which gives it the solid-state and durable finish (and watertight).

I've managed to get the SWR to 1:1!

A few last things to note. A small antenna such as a rubber duck antenna (or even a mag-mount antenna) attached directly to a radio will give different results based on the size of the radio, what's connected to it, and the things around it. The reason for this is that the antenna tuning is affected by the "counterpoise", which in the case of a rubber duck is the radio itself. (If the antenna is outside or better isolated from the radio, the readings should be the same.) Since things like rubber ducks won't be the same with an outboard SWR meter connected or the same as an antenna analyzer might show, the only way to know what the SWR is for a particular radio and frequency with a particular configuration of power supply, microphone, people etc, is to read the SWR off the radio. Of course if that's not accurate, you're not getting the right information.

The Telescopic MurDuck RE-A144V2P

Same principle, but using a telescopic antenna of 30 cm in length. Being telescopic it can be used for more then one frequency. I also put a 3 pF capacitor inside the coil and soldered on both ends of the coil (making it parallel resonant). The "block" frequency lies way out of the VHF or UHF HAM bands. 144...148 or 420...440mc are easily passed through, making it dualband. The frequency that's being blocked is about 290 Mc +/-.
Instead of a BNC connector I used a SMA connector.

Coil dimensions: 6.5 turns, 4mm inside diameter, 0.6mm wire (+/- 100nH)
Inside the coil: a 3pF capacitor

 finished

I used a SMA connector for use with my Yaesu VX-1. The included "petite" rubber duck isn't worth much. This has made a huge difference not only for VHF/UHF, but also outside the ham-bands as this little VX-1 thingy has wide reception.

To test and tune your telescopic dualband antenna the same principles described above (MurDuck) applies here too.

The tank resonance formule: 2*pi*F= 1/sqrt(L*C) => 291 Mc block frequency

Have fun and my best 73"

Guy, ON6MU
http://www.qsl.net/on6mu

Home
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ON6MU

ON6MU's "Vipormutant" Antenna RE-AHFV14P

Versatile Inexpensive Portable Multi-band Tunable Antenna

de ON6MU
revision 2

Features

- Only 3 meters high fully extended (effective radiating element height)
- Less then one meter inserted (no element is larger then one meter including the tunable section)
- Tunable without the use of an extra tuner (just switch till you get the best SWR)
- Covers all frequencies from UHF to 7 MHz without a tuner
- UHF (tuned by de- or increasing the length of the antenna) 3/4 2*5/8 4*5/8
- VHF (tuned by de- or increasing the length of the antenna) 1/4 5/8 2*5/8
- HF (tuned by switching)
  6 meters (1/4 1/2)
  10 meters (1/4)
  12 meters
  15 meters

17 meters
20 meters
30 meters
40 meters: with large counterpoise and/or with longer radiating element, or extra tuner
80 meters: if radiating element is > 5 meters, or with large counterpoise and/or with extra tuner

- Works with or without cointerpoise
- Ideal as portable or balcony antenna
- Compact and extremly portable
- Not too critical on the material or sizes of the elements
- +- 50 watt input
- SWL's Note: tunable on all frequencies between the bands mentioned above

What you need to build the "Vipormutant"

- 5 (or more depending on how high you want your boom) alu tubes
- piece of hard insulating tube (+- 7 cm), examples: plastic, nylon, bamboo...
- some low loss RG174 50 Ohm coax
- carbon/ferrite bead or toroid (to act as a choke)
- a few meters of 0,75mm enamelled copper wire to make the coil
- SO239 (PL259 female)
- Paint, silicon, glue etc. to seal things up
- Plastic box to mount over the coil and where we'll put the switch and SO239 connector
- 12 position rotary switch
- a few innox hose clamps

About the "Vipormutant" antenna:

Well yes, one must have a name HI...It is nothing more then a base coil loaded antenna, but with a selector direct on the base to tune the antenna.
Most of us don't have the luxury of building a 1/4, 1/2 or even a 5/8 wavelength vertical antenna for HF. We have to settle for something a little shorter. (A lot shorter, in the case of people following the FCC's Part 15 rules, which limit them to 3 meters in size.) Shorter vertical antennas can give acceptable (but not spectacular) performance.
I needed a highly (HF) portable antenna to use with my FT-817 which should have the highest possible frequency range (also VHF) and still compact enough to take along almost anywhere! The antenna should be versatile enough to allow further experimenting, to allow being mounted on a balcony, caravan, outdoors etc... So I came up with a compact vertical (dismounted no higher then 1 meter) with a "tuner" directly connected to the antenna radiating element (the best possible place a tuner can be).
The "Vipormutant" tuning principle gets energy into the antenna on a wide range of frequencies, but the design of an antenna is what controls what happens to the RF energy from there. For some antennas, the antenna is simply not complete without a radial system, or at least a counterpoise. Other types of antennas need no RF ground system at all. Most reference books on antennas provide solid guidance on radials and counterpoises, but only for antennas cut to a specific frequency. When using the "Vipormutant" it will also act like tuner and at the best place a tuner should be: directly beneeth the antenna! So the rules have to change somewhat because the "Vipormutant" almost operates across the full range of HF frequencies unto UHF. It doesn't need a counterpoise to work, but the efficiency will increase when you do use it.

Considerations:

- If the length of the conductor is very short compared to a wavelength (< wave/4), the electric and magnetic fields will decrease dramatically within a distance of one or two wavelengths.
- It is impossible to make a small antenna to radiate as efficient like a big antenna.
- Ground losses affect radiation patterns and cause high signal losses for some frequencies. Such losses can be greatly reduced if a good conducting ground is provided in the vicinity of the antenna.

The coil/tuner

Wind 0,8mm enamelled copper wire around the isolator (+- 16mm diamter) and make a tap every xx turns (see fig. 2 and 3)

Fig.1

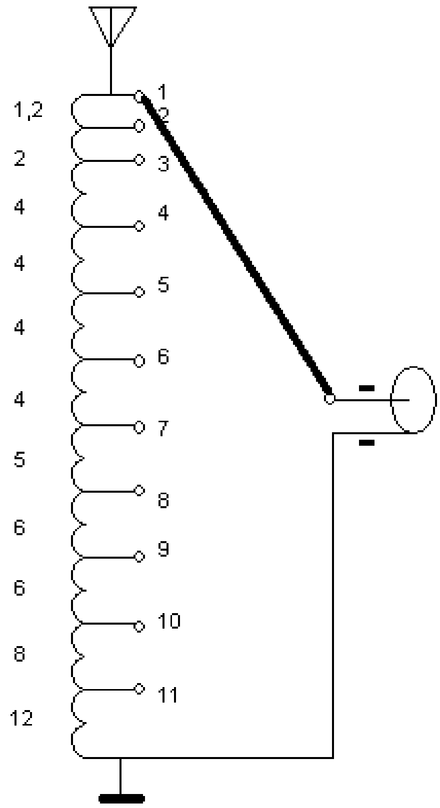


Fig.2  The coil dimensions isn't too critical.

Relatively short antennas behave like lossy capacitors and present a high impedance load to the transmitter due to the large amount of capacitive reactance that is present. The loading coil helps to tune out that reactance. Tuning out the reactance is important because a tuned antenna will accept and radiate much more power than a mismatched antenna.

When the loading coil is installed at the bottom of the vertical radiator, we call it a "base loaded" antenna. Base loading requires the smallest amount of inductance to achieve resonance.

The shoke

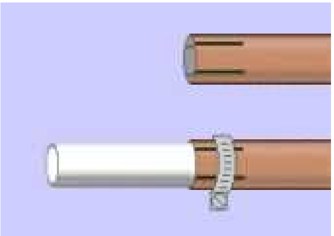
Is made out of miniature 50 Ohm coax (rg174) that goes a few turns through the carbon/ferrite bead or toroid. You can also use a Snap-Together Ferrite Choke Core.
If a ferrite is put over a cable which includes both signal and return lines, it will have no effect on the signal (differential-mode) current but it will increase the impedance to common-mode currents. This is because the differential currents, by definition, sum to zero in each wire pair and therefore there is no net magnetic field. If there is no field, the ferrite is invisible. But the common mode currents do produce a net magnetic flux and this flux is concentrated in the bulk of the ferrite, leading to an increased impedance for these currents only. The choke should prevent any mantle currents flowing and should decrease RFI.

The effectiveness can be increased by looping the cable several times through the core, but the benefit is limited at higher frequencies by the stray capacitance between the turns of the cable.

Fig 3.

4 turns

The base insulator

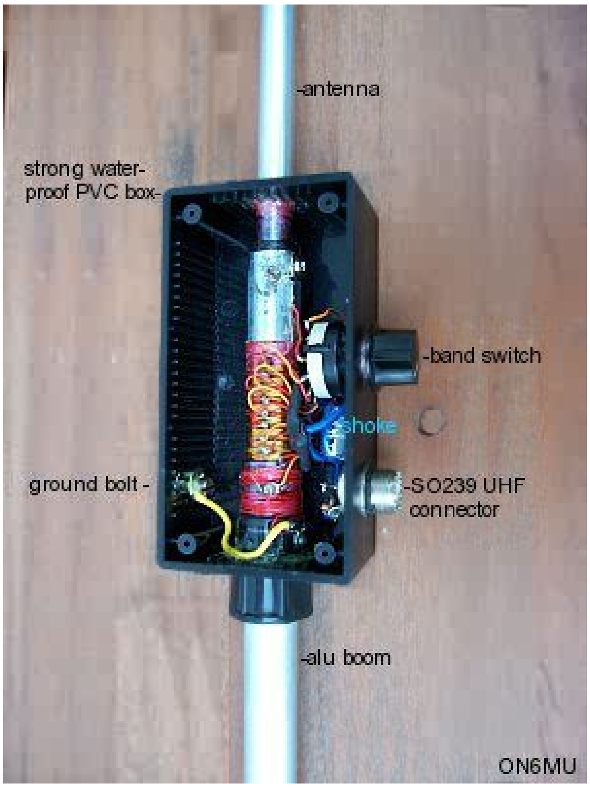


The vertical radiator "driver" element and tuning box

I used a plastic box of 130x70x40mm. On top and bottom I drilled a hole to fit the driver element (radiator of +/- 40cm length)and boom (also +/- 40cm length).
On the side I drilled a hole for the rotary switch and the SO239 connector, whilest on the opposite side I drilled a hole to fit a "ground" bolt where I can easily connect the counterpoise and/or ground to if needed.

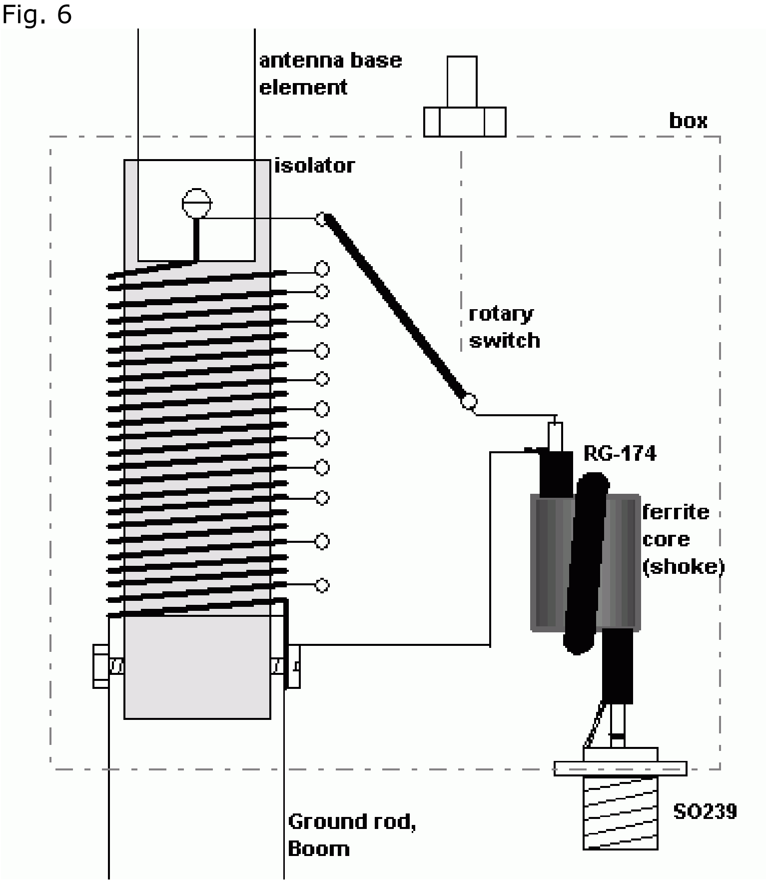
Fig 4

Fig 5



This is how things are connected inside the box:

Fig. 6



Example

The rotary switch is used for tuning the antenna on each band. The first position allows UHF/VHF ranges.
Tuning is done by sliding in/out of the elements.
The "lower" the switch (higher inductance) the lower the resonance frequency of the antenna.

Remember, and this is important too, to seal everything up so no moisture can penetrate the antenna!
Because the radiating vertical antenna elements are made out of separate pieces that fits inside each other and are tightened by hose clamps, the construction isn't waterproof.
If you use a hollow isolating piece you need to to prevent moisture from getting inside the box (via the places where the elements are hold together). I've used a rubber "stopper" that fits snugly on the bottom of the driver element and glued tight.

Black paint finishes the job:

fig. 7


using a round box

In my first design I used a plastic box of 50mm diameter and 9 cm heigh. On top I drilled two holes: one for the driver element (radiator of 40cm) and a hole for the rotary switch (as was used in the first prototype).

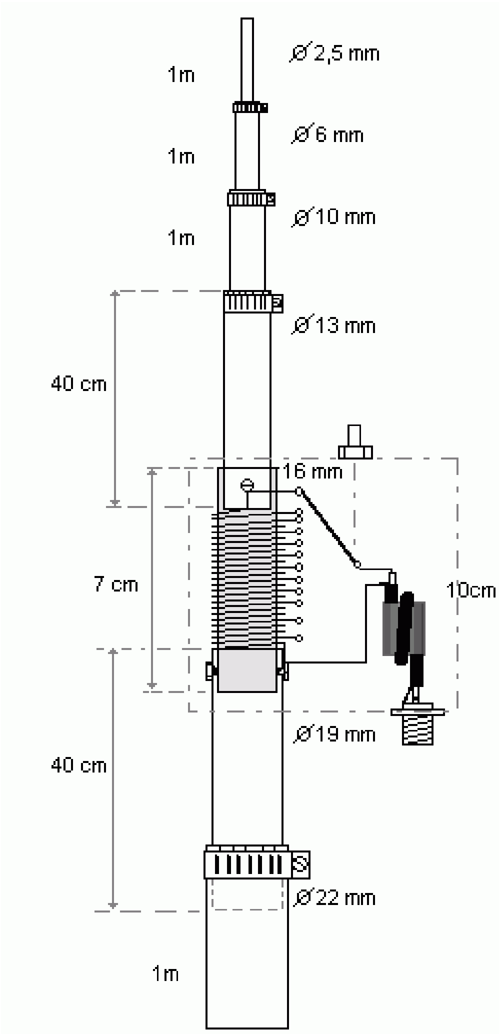
fig.8: The main driver element and tuning unit finished

This allows it to be used on almost any boom or can be extended to use with or without vertical elements! Ideal for experimenting!

Featuring Today

The antenna construction specs

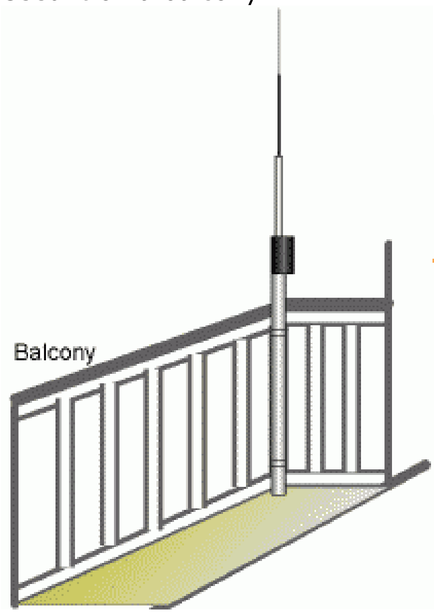
All elements are made out of aluminum.
Fig. 9

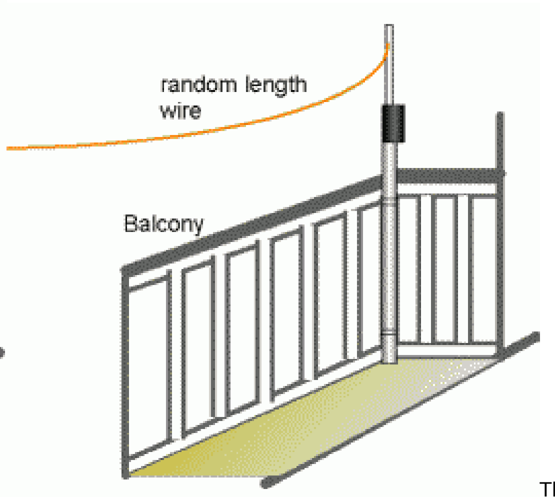


This makes the antenna effective radiating elements a total length of 3 meters. The boom elements can be chosen freely and on your needs. A short one (one element of a meter), a medium sized one of several 1 meter tubes or none at all! The bottom piece where the boom is "connected" too is 40 cm and can/could be put directly in the ground (if made pointed for sure). Or you could fix it in a umbrella stand. Use your imagination HI.

Examples of "Vipormutant's" utilization

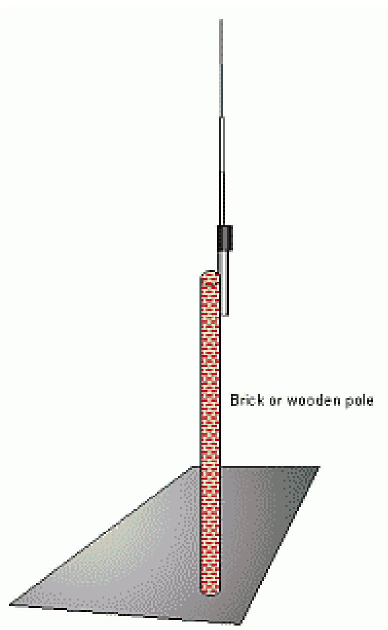
Used it on a balcony:

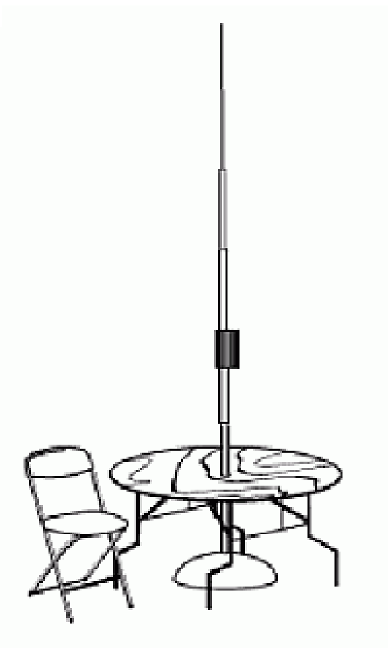




This could cover even the lowest HF-bands!

Use it outdoors without grounding:

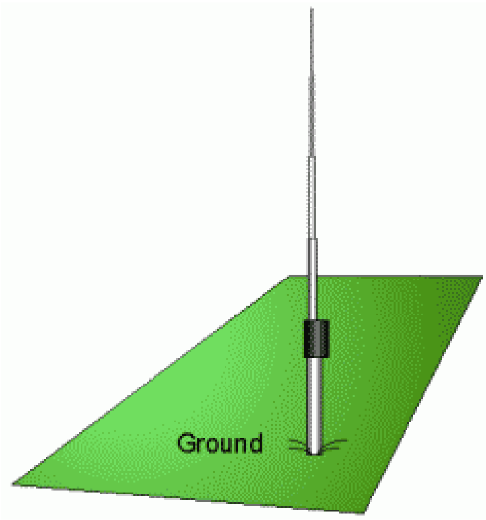


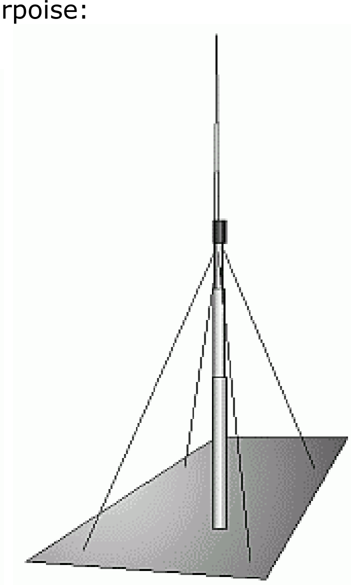


Use it outdoors as a shortened "dipole" balanced antenna
(rotary switch set approx. in the middle):

Frequencies below 7 MHz could easily be match 1:1 SWR if total length of the "dipole" > 4 meters
Further tuning can be done with selecting a different impedance using the rotary switch.
Different lengths of wire can be used (an example: one part 3 meter, the other 5 meter or more)

Use it outdoors with ground or counterpoise:





Radials and Counterpoises basic purposes:

1. To improve the RF ground conductivity for the ground current return path. Unless you live in a salt-water swamp, your ground conductivity makes a very poor path for the return of ground currents. This increases the ground losses and reduces the efficiency of an antenna that needs a good RF ground.

2. To provide a counterbalance for the feed point of the antenna to reduce RF radiation back to the radio room. The "Vipormutant" changes the rules because there is no single frequency that you will be operating on, so all of the thumb rules for 1/4 and 1/2 wavelength radials don't apply. It is possible to be either a purist or a pragmatist in deciding what radials to put in place.

3. Number of radials: More is better, up to a point. In carefully controlled experiments, it has been proved that increasing the number of radials from 2 to 15, or from 4 to 16, produces significant increases in signal strength. Further increasing the number of radials to 60 only produces 1 to 2 dB of increase in field strength. Follow this link to see some of the empirical data.

4. Where to put the radials: For a semi-permanent installation, it is customary to bury the radials a few inches down in the soil. This makes it much easier to mow and walk in the area around the antenna. However, some experimenters have gotten an improvement in performance by raising the radials and the antenna base a few inches above the soil. Raising the antenna and ground system several meters above the earth, for example by installing the base of the antenna on a roof-top, can improve the antenna's performance by reducing capacitive earth losses.

While the "Vipormutant" will provide a good match with a poor RF ground system which will will able you to transmit, your antenna efficiency will be low. Nevertheless, by using a tuning circuit directly at the antenna

radiating element losses are kept to a miminum. Getting the greatest efficiency out of your antenna system needs a proper RF ground unless you're using a balanced antenna system

The efficiency of the antenna increases by using a counterpoise. However, the antenna can be tuned perfectly without!

Don't forget to check these out:

ON6MU Homebrew projects
Radioamateur related projects

ON6MU Ham mods
Modifications of transceivers

73"

Have fun and my best 73"

Guy, ON6MU
http://www.qsl.net/on6mu

Comments, pictures or experiences with my antenna are always welcome!

ON6MU

Homebrew Coaxial Dipole for VHF or UHF

Here's a base station antenna you can easily build for 146, 220 or 440 MHz. Performance is equal to a J-pole, but it's smaller, less obtrusive and more weatherproof.

John E. Portune, W6NBC

Hams like to build antennas, especially if they're made from ordinary hardware store items and can be assembled with common hand tools. Here is a homebrew coaxial dipole built from a small stainless whip, a length of threaded table-lamp tubing and some ¾ inch copper and PVC fittings. The one shown is for 440 MHz but it can readily be scaled for 146 or 220 MHz.

For homebrew vertical VHF antennas, coaxial dipoles often play second fiddle to J-poles. That's because the center connection to coax is often difficult to fabricate in the home workshop. Yet both antennas have the same performance. They're both full sized, half wave vertical dipoles, and the coaxial is shorter.

Making a Coaxial Dipole

If you start with a common half wave ($\lambda/2$) stainless whip and extend it all the way down through a $\lambda/2$ long support tubing, here made from a threaded table lamp tube, the lower part of the whip becomes the center conductor of a short length of rigid coax feeding the center of the antenna. Now connection to normal coax is easily made below the antenna. To form the rigid coax section, you'll need to insulate the center conductor (lower part of the stainless whip) from the lamp tubing with some ¼ inch inside diameter (ID) polyethylene tubing. Hardware stores normally carry it. This short length of rigid coax formed in this way isn't precisely 50 Ω characteristic impedance, but the difference is totally insignificant. The drawing in Figure 1 shows the details.

Assembly Details

The bottom half ($\lambda/4$) of the radiating dipole is a coaxial sleeve made from ¾ inch copper pipe and a pipe cap. The coax feed runs up its center to the connector at the bottom of the lamp tubing. Support and insulation of the bottom of the sleeve is provided by a ¾ inch CPVC plastic pipe cap. For those not familiar with CPVC fittings, they're made to mate with copper pipe and can handle high water temperatures. That's not true of common PVC fittings. Most hardware stores now carry CPVC. Drill a ⅜ inch hole in the center top of the copper and the CPVC caps for the lamp tubing to pass through.

The whole antenna is held together by two lamp tubing nuts and a plastic lamp finial, also readily available at hardware stores (see Figure 2). Note that a lamp tubing nut is also required inside the copper pipe cap. Drill a small hole in the middle of the lamp finial for the stainless whip. On the bottom of lamp tubing below the antenna install a 1¼ inch common PVC pipe cap, and secure it with two more lamp tubing nuts. This gives you a way to easily mount the antenna on top of any convenient length of 1¼ inch

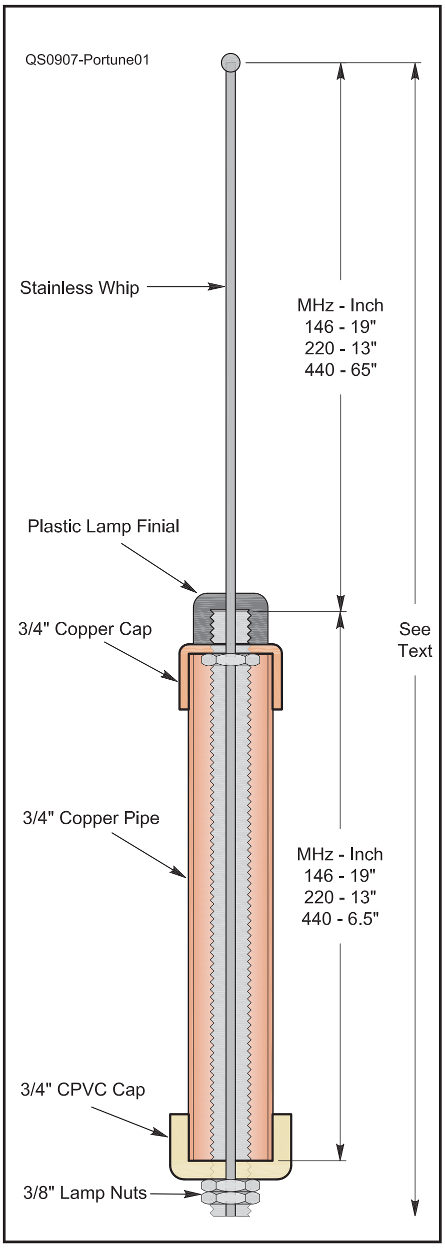


Figure 1 — Dimensioned drawing of coaxial dipole for three bands.

PVC pipe. Run the coax feed down through the PVC pipe.

Hooking it Up

A conventional PL-259 UHF type coax connector for RG-8 coax will actually screw onto the bottom of the lamp tubing. The threads are not a perfect fit, but will tighten satisfactorily. The stainless whip runs down all the way to the very tip of the PL-259 connector. Solder it in there. Before doing so, however, install all the pieces of the antenna onto the threaded lamp tubing.

Many hams may think that stainless steel won't solder. It definitely will with a hot iron and acid flux. Scrape the end of the whip and dip it in hydrochloric swimming pool acid. With a little action from the tip of the soldering iron the whip will tin perfectly well. Before soldering, however, grind two or three small side notches in the bottom end of the whip. A Dremel tool works well for this. The notches will help the solder securely lock the whip into the tip of the PL-259 connector. Neutralize any leftover acid with baking soda solution.

Perhaps surprising to some, it really isn't necessary to solder any other parts of the antenna. There is adequate mating surface at the joints for the RF to cross over efficiently. Do, however, seal all possible water access spots with common silicone RTV glue and or plastic electrical tape.

Make it for the Band You Like

There isn't an exact length required for the lamp tubing or the stainless whip. These merely need to provide enough space for all the pieces of the antenna to go together. I had a 48 inch whip on hand that I used uncut for my 146 MHz coaxial dipole and a similar 17 inch uncut whip for 440 MHz. I merely cut the lamp tubing to an appropriate length to fit the whips. What does matter, however, is the length of the whip above the top of the lamp tubing as well as the length of the coaxial sleeve. These need to be close to a λ/4. For 440 I used 6½ inches, on 220, 13 inches, and 19 inches for 146 MHz. These antennas are quite broad band and will cover the entire band in each case with these sizes. No cutting or pruning is necessary.

For ruggedness, or perhaps for stealth, you can install the whole antenna inside of 2 inch PVC water or ABS soil pipe and close the ends with end caps. I live in a mobile home park where antennas are not permitted, but my landlord thinks my coaxial dipoles (in ABS pipe) are vent pipes.

Try out one of these homebrew coaxial dipoles. You may find you prefer its smaller size, less obtrusive appearance and superior weatherproofing as compared to a J-pole.

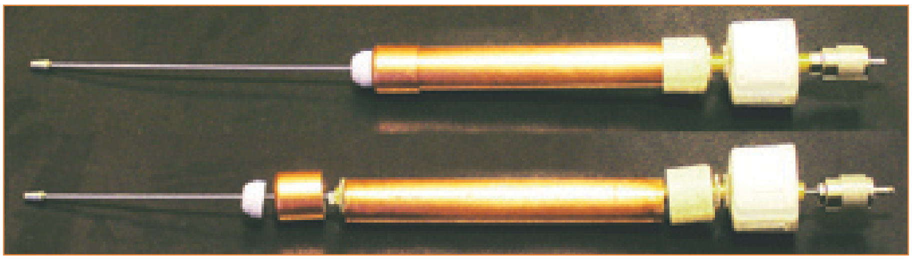


Figure 2 — Details of final assembly of coaxial dipole.

ARRL Member John Portune, W6NBC, received a BSc in physics from Oregon State University in 1960, his General Radiotelephone license in 1961 and his Advanced class amateur license in 1965. He spent five years in England as G5AJH and upgraded to Amateur Extra class in 1985 to become a volunteer examiner (VE). John retired as a broadcast television engineer and technical instructor at KNBC in Burbank and then from Sony Electronics in San Jose, California.

John is active on many bands and modes, predominantly from his HF RV mobile station. He has written various articles in ham radio and popular electronics magazines and remains active as a VE team leader, ham license teacher and Web site designer. You can reach John at 1095 W McCoy Ln #99, Santa Maria, CA 93455, or at **jportune@aol.com**.

It was used not so long ago in VE3 by Jack, G0SNV, and was again used by GM3VLB on OC-121 in 2003 and again as a "back-up" antenna on his 2005 expedition to the Pacific and VE7 IOTA islands with Alex GM0DHZ and son Niall VP8NJS.

The basic design centres on the use of a 4-section, 4m-long fibreglass fishing rod. These were originally purchased in French hypermarkets (very cheaply, at around £1 per metre for the shorter rods), but are now available in the U.K. The SCOTIA team would recommend Sandpiper Aerial Technology for both quality and value). GM3VLB has also produced various similar models for more efficient use on the LF bands, again using fibreglass rods ranging in length from 5m to 11m!

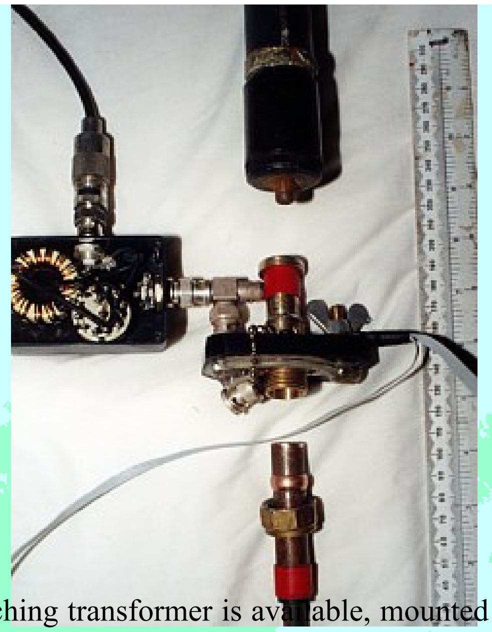
A common feature has been the provision of a 3/8" UNF bolt at the bottom of each "fishing rod". This allows the antenna to be screwed into either a vehicle mount or a ' ground mount'. The 4m version has also often been used overseas, roof-mounted on stationary rental vehicles, using a 'mag-mount' modified to accept 4 radials draped over the vehicle.

All antennas can be mounted on the tailgate mount of the GM3VLB's Ford Sierra Estate (even the 11m high 160m version, although it has not yet been used *in anger*, and certainly not /M!). As the majority of Scottish islands are inaccessible to vehicles,earlier verticals were mounted on the ground-mount assembly.

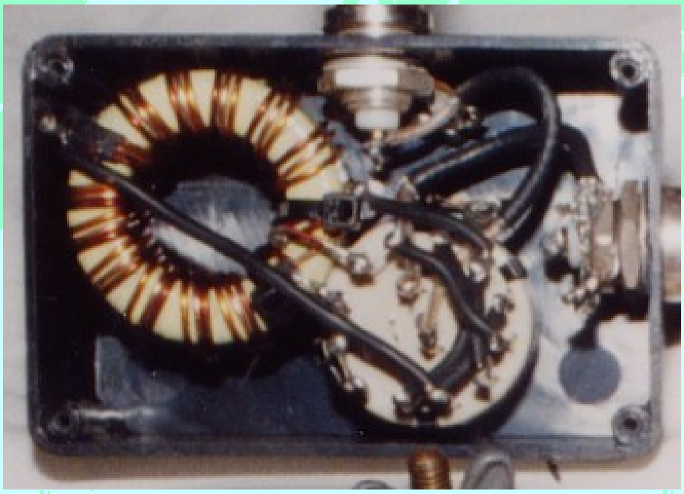
This consists of a small base plate supporting a CB-type 3/8" UNF socket, a BNC socket and a brass wing nut to attach the radials. Using whatever ' plumber's hardware' is to hand, this is supported by, but insulated from, a ground-post about 50cm long made, in the André's case,

from old tank-whip sections (light but strong) with a pointed end (e.g. a nail) to ease insertion.

More recently, the 5m ***"Islander"*** has become the mainstay of all island activation.A recent development is a clip-on baseplate with provision for direct connection of the coax feed-line and the radial system. The vertical can be mounted directly on the ground, either using a "ground-spike" as above, or held in place by a simple, triple guying system.

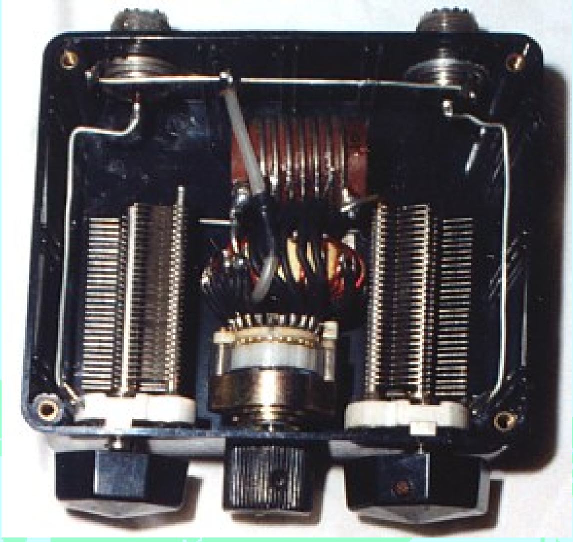


Although seldom required, a small, home-brew, base-matching transformer is available, mounted in a small ABS plastic box (75 x 50 x 25mm) with appropriate BNC plugs and sockets.

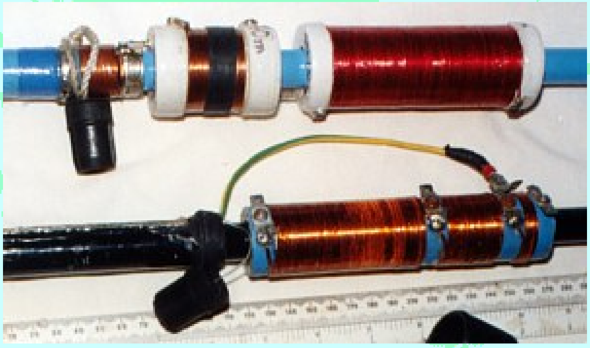


There can be not the slightest doubt that one of the most useful items of equipment ever produced for the antenna experimenter is the MFJ-259 type of antenna analyser , one of which accompanies GM3VLB on ALL expeditions. As this is still a relatively expensive item for many amateurs, GM3VLB has recently designed an ultra-simple/cheap version (based on an original design by Jim Tregellas VK5JST) which it is hoped to describe shortly in RadCom and on this web-site.

GM3VLB also has available a very small, homebrew, T-match ATU consisting of two 200pF trimmer capacitors (modified to have small 1/4" shafts) and a switched toroidal inductor. This can be used, if necessary, to match an antenna that may be *slightly* off resonance. It was used for example in the N.W. Territories (VE8/GM3VLB) when, with an outside temperature of -20°C or lower, it was found that the 4m version, already adjusted for resonance on 15m, could also easily be tuned for use on 10m, 12m, 17m and 20m without having to venture outside!



As stated earlier, longer versions have been built, but most designs have centred on the 4m fishing rod. The original Mk1 version used one 'fixed' coil for 20m, and two separate 'plug-in' coils for 40m and 80m, whilst some later versions use a tapped loading coil that was wound on a length of 32mm diameter yellow (or blue) plastic water/gas (?) pipe which slides over the fishing rod, to sit on the first joint.



A wire, bonded to the outer tube (with two-part epoxy resin, fibreglass resin or similar), connects the 3/8" UNF screw to the base of the coil. This coil (107 turns of 20 SWG enamelled copper wire) has two taps, one at 72 turns (which, when shorted, leaves 35 turns for 40m) and the other at 100 turns (which, when shorted, leaves 7 turns for 20m). The whole coil (107 turns) is used on 80m. (The exact number of coil windings will obviously depend on the precise diameter of the coil former used).

The radiating element was initially a length of very thin (1mm), 7-strand Teflon-covered wire hanging from the top of the rod and plugged into the top of the loading coil. This was used on all three bands. Other shorter wires could also be used, with no loading coil, to resonate on the 10, 12, 15, and 17m bands, and with the 40m coil, on the 30m band.

More recently, the coils have been wound directly onto the top of the outer base section

The radiating element can also be made to be continuously "adjustable" by using bare, fairly flexible, thin multi-strand wire wound in place of the steel tape, onto the reel of a modified tape measure. The modification includes a simple but efficient sliding contact arrangement. By using

bare wire, this eliminates the inductive effect one would have with a reel, or coil, of insulated wire. With this arrangement, and the MFJ-259, band changing becomes extremely simple and accurate. A mini-pulley system is used to carefully pull the wire "back up" the fishing-rod when going down in frequency.

The most recent design now uses a 5m fishing rod. The silver-plated paxolin-mounted coil was salvaged from an ex-MOD 'roller-coaster' unit and modified with plastic end-plates, with holes cut to allow it slide over the fishing rod and thus sit at the top of the base section. Some EMC 'finger-stock' (obtained at an Amateur Rally) was bent and formed into a complete 'ring', which slides up and down the coil, shorting out a selected number of turns in the process. The 'tape-measure radiator' plugs into the top of the coil. A green (more UV-proof) soda drinks bottle (also with a Canadian connection !) is adapted to keep the whole assembly dry.

Yet a later 5m version uses a small home-brew *roller-coaster* type coil which allows rapid tuning of all bands from 10m to 40m. An additional *fixed* coil wound on the rod's outer casing, provides the additional inductance needed to cover the 80m band. More recently, and as described elsewhere, the 5m ***"Islander"*** has been introduced. This uses a novel continuously adjustable coil (similar to, but considerably smaller than the ex-MOD version above), and again covering 10m to 40m but also the whole 80m band using a plug-in additional coil.

As with his island multi-band inverted 'V', GM3VLB uses an approximately 45' length of 50ohm RG58 coax that, after correction for velocity factor, is a half-wavelength on 40m, two half-wavelengths on 20m, three on 15m and four on 10m. Previously, 4 radials were used. The radial system consised of two pairs, each pair connected to a U-shaped spade terminal clamped by the wing nut on the base-plate. They were made from 5-way computer ribbon-cable, trimmed back to be a 1/4 wavelength long on each band from 10m to 20m. The same radial system was used on 30m, 40m and 80m and in most situations appeared to work satisfactorily, although the preferred antenna for these bands remains the *GM3VLB's Multi-Band Inverted-V* described on this site and elsewhere (e.g. RadCom, March/April 2005). It does however require a certain amount of space - not always available.

Just as, in GM3VLB's opinion, Mike Grierson G3TSO has made a significant contribution to our knowledge of mobile antennas, then so has the work on vertical antennas by Ralph Holland VK1BRH ("Short Vertical Antennas and Ground Systems", Amateur Radio 1995) and that of

Kenny Silverman, K2KW, and his team. The extensive work of the latter can be seen on his web-site, in particular "Verticals for Contest Operations" (CQ Contest Magazine, March 1998) and "DXpedition Antennas for Salt water Locations - A Study on 20m Antennas". Both works are examples of research at its best.

GM3VLB has studied the findings of these two independent groups and feels that they reach several similar conclusions that he now tries to summarise:

1. Ground-mounted radials lead to very much reduced efficiency

A significant improvement in efficiency (from almost zero up to of the order of 30%) has been noted for heights above ground as low as 0.005-*lambda* and up to 0.05-*lambda*. In recent years, GM3VLB has increased the length of his original ground-spikes and/or the position of his base-plates, to allow the radials to be raised to 40cm or more above ground, representing approximately 0.005-*lambda* on 3.7MHz and 0.04-*lambda* on 28MHz).Garden canes with nails embedded at one end, are used to support the ends of the radials. Whilst no detailed comparative tests have been carried out, we have a very strong feeling that these "*raised radials*" have indeed given better results....

2. Large numbers of radials are unnecessary

K2KW and his team have primarily used only two radials on their CQWW winning verticals, even on 160m. Here again, the SCOTIA team have not carried out detailed tests, but have adopted the principle that there is little or no advantage to using any more than two radials, the same two radials being used on ALL bands. Whenever posible, these are mounted at 180 degrees to each other.

3. Short verticals, ground-mounted by the sea, can out-perform full-size mono-band Yagis

For angles of radiation below the so-called pseudo-Brewster angle (~12º), the sea-reflected waves are in phase with much of the "direct" waves, thus giving rise to reinforcement. This results in appreciable gain at low angles over the Yagi, which even if several wavelengths high and multi-element, has a relatively deep null at such low radiation angles. In practice, an expedition-type multi-band Yagi is unlikely to be mounted at a height greater than 1/2-*lambda*, even on 28MHz, resulting in the angle of radiation of the main lobe being **above** the pseudo-Brewster angle (in fact, over certain paths, K2KW reports that on ". . . many occasions . . . a signal was S-9 on the verticals (on the FT-1000-MP) and S-0, and almost unreadable, on the horizontal Yagi").

4. Shorter radial lengths may be adequate

The effect of radial length is less clear but one interpretation is that short radials may be satisfactory for short verticals. Radial lengths in the range 0.1-*lambda* to 0.15-*lambda* are suggested, with 0.25-*lambda* offering little advantage, except perhaps with 1/4-*lambda* radiating elements. It had been the intention to carry out comparative tests, but once again, considerable experience with a single pair of short radials tends to confirm the "short radial" idea. A 0.2-*lambda* radial on 14MHz for example, will be approximately 0.1-*lambda* on 7MHz. It will be 0.4-*lambda* on 28MHz. It must be said that as conditions on 10m have been very poor since we implemented the "short twin radial" concept, we have not been able to thoroughly test the performance of radials *longer than* 0.25-*lambda*. Indeed, Alex GM0DHZ had some difficulty (during his pre-3V8SS expedition tests) tuning a ***"Traveller"*** using 0.4-*lambda* radials. Maybe we need to do some further tests before 10m begins to open up again.

5. Distance from the sea/land boundary affects gain

There is evidence of an increase in gain of about 3dB as the vertical antenna is moved back to about 0.25-*lambda* from the sea/land boundary. At 0.5-*lambda* the gain drops to -2dB, rising again to +2dB at 0.75-*lambda* No figures are given for greater distances, but in terms of choice of site, the interpretation is obvious (even taking the tide into consideration, operating close to a cliff-edge above deep water, would seem best!).

The proof of the pudding

In 1997, the 6Y4A CQWW CW team, using ONLY verticals, narrowly missed the N. American record with their claimed score of over 31 million points! The team subsequently operated, not only with great success as KH5K from Kingman Reef, but also more recently from Jamaica with QRP.

Although the results obtained with the various versions of the GM3VLB multi-band vertical have always been extremely gratifying, despite the fact that the radials were initially always simply laid on the ground, we have now adopted the *"raised radial"* technique. Whilss we cannot irrefutably *prove* the results now obtained are better, we have a strong feeling they are - they are certainly no worse. With Andre's back-ground, he appreciates *scientific method*, but regrets to say that once on an island, the high QSO-rate takes priority over setting up a proper antenna test-site! The intention is always there, but basically, if we are being called, the antenna is *working*!

We should perhaps admit that there have been one or two occasions when, inexplicably at the time, it proved virtually impossible to load up the vertical antenna on the 80m band. One instance was on Isle Martin (CN31). On that occasion, the MFJ-259 analyser was then not yet available, but it was found that several "temporary turns" added to the loading coil, allowed some power to be radiated. K2KW reports similar problems. If K2KW is correct, then raising the radials might have solved the problem. More recently on Uyea (SI24), serious de-tuning on 80m was eventually put down to unavoidable proximity to a large corrugated iron shed, as a few hours later on the next island, the same antenna behaved perfectly normally!

Conclusion

It would seem the advice is simple. When operating /P from islands, forget about climbing to the highest point. Forget about cumbersome Yagis, rotators, amplifiers etc. Select a site as close to the sea as possible, ideally surrounded by water (Kingman Reef would seem ideal!) and use a vertical (0.25-*lambda* or less) with a couple of radials, preferably raised and no longer than the radiating portion of the antenna.

Looking back, GM3VLB now realises why certain sites have provided nothing short of outstanding results. In all cases, they were either the ends of long piers or narrow spits of land jutting out into the sea. Next time you are /M on Jura, try the end of the pier at Craighouse, or the one on W. Burra in Shetland, or at Broadford on Skye - or the many other similar sites available in Scotland. Frequently in the past, André has found that his multi-band verticals performed *better* when vehicle-mounted than when ground-mounted. Could this be because the vehicle body is in effect a raised radial system, whereas he has was always used to laying his radials directly on the ground?

GM3VLB recently acquired a 'monster' 11m long roach-pole. If a 4-metre rod can be used effectively on 80m, might an 11m one offer reasonable performance on Top Band? After all, many "mobileers" obtain quite pleasing results on this band with the ubiquitous "8-foot loaded-whip". Noting that a recent CQWW CW 160m contest was imminent, a makeshift support was crafted, allowing the 'monster' to be attached to the fence between his gable-end and that of his neighbour. For most of its length, the rod was less than 3m from both gable-ends. A temporary "*roller-coaster*" type coil was suspended at the base of the rod that was about 2 metres above ground level. Following K2KW's suggestions, only two radials were used (each about 10 metres long, the same length as the vertical section), one running to (and finally down) a 2-metre pole at the pavement end, the other running along, and in contact with, the gable-end wall. Both were over tarmac - hardly the ideal DX antenna!

The operation was spread over 3 short sessions, one early on the Saturday morning, and one on each of the Saturday and Sunday evenings, and totalling about 8 hours. The object was to contact as many countries as possible on 160m without recourse to the DX-cluster. *All* "new ones" were

to be found by listening (as we used to do in the old days!!). The station was a Kenwood TS140-S, a mini-ATU and home-brew keyer. Output power was less than 100W

The conditions did not appear very good, the same two-dozen or so "big guns" being heard each "session". A total of 57 QSOs were made in 26 different DXCC countries. No doubt some, with their sky-high monster antennas and their kilowatts of ERP, will think this is pretty pathetic, but André was very satisfied (back in the 60s and 70s, it took him years, even as 5Z4KL, to work 26 countries on 160m and 3 years to make WAC 160m!). The pleasure was all the more when on the Sunday, Alex GM0DHZ (his regular island partner) informed him that the "SO6Y" which he had got "first call" and thought (in his DX ignorance) was Poland, might be Western Sahara! Hearing that station make frequent, unanswered, lengthy CQ calls on the Sunday evening, GM3VLB called and worked him again! 7 other countries (including the USA and a UA9) were also heard but not worked. Next time this antenna is tested, it will be under island conditions. GM3VLB has high hopes that this very simple, very light, very easily erected 160m vertical will then give an even better account of itself.

In 2003 André activated OC-121 and OC-019 again, prior to teaming up with son Niall (VP8NJS/GM6GMZ) and friend Alex (GM0DHZ), to activate several VE7- Islands / NA-Groups. Despite extraordinarily poor propagation, the vertical antennae used on the expedition worked well. However, there remains plenty scope for further experimenting with these and other antennas. Please look for us, especially on 160m and on CW, which Alex intends to give a bigger airing to in the future.

Details of all known intended activity will be posted on this web-site, or via e-mail via our extensive mailing lists (if you wish to be added, please e-mail gm3vlb@btinternet.com). In the meantime, please feel free to contact him regarding any aspect of these and other antennas described elsewhere (see the links below), and also for details of any particular item of associated home-brew hardware.

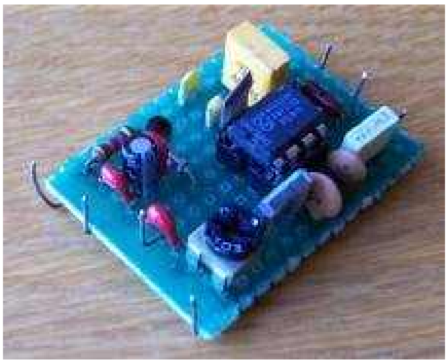
See also the GM3VLB Multi-Band Inverted-Vee Dipole
the GM3VLB Mini-Delta
the SCOTIA Bandhopper Multi-Band Mobile
the SCOTIA Poor Man's Antenna Analyser

and the GM3VLB Expedition Equipment List

Home Page	The SCOTIA Programme	Latest News & Future Activity	Past Island Activity	Equipment and Antennae	
GM3VLB - My Background	Hints for Activators	GM3VLB and QSL-ing	On the subject of Donations	Special Issue QSL Cards	Special Issue Postage Stamps

DRM
MF 455kHz -> AF Converter
RE-RXC0455/0012
(455kHz down converter)

MFC revision 1.4



MF (455kHz) to AF (audio frequency) Converter/Interface
to receive DRM singals your shortwave receiver, like the Yaesu FRG-100!
and FT-817/897

Please take also look at our Digital Analog Demodulation Project (DADP, VE7DXW)

Attention! The modification will be done at your own risk!

About the MF-LF converter/mixer RXC455/0012:

This is a very sensitive homemade MF converter/interface allowing you to receive the DRM radio (Digital Radio Mondiale) with your general coverage receiver and a soundcard. It can also be used for software radio apllications, and other MF to LF experiments (not just DRM, and surely not just for the Yaesu FRG-100)!
I've tested this project on a allmode Yaesu FRG-100 receiver. Within certain limits you can change the output bandwidth frequency to suit your needs. The converter is very stable, low noise, sensitive and low on power consumption.
The heart of the converter has been built around Philips SA602 (NE602, NE612, SA612), a twice balanced mixer oscillator. This IC finds his applications in layer capacity communication systems, cellular radio applications, RF data left, VHF-transceivers, broadband LAN's ed. IC in a ordinary 8-pin dual-in-line can be bought implementation (DIP) or 8-pin SO (surface-mount miniature package) implementation. Both implementation has a low cost. SA/NE602 a very low usage of only 2,4mA has! The total usage of the converter amounts to only 13mA. Therefore also uncomplicated usable applications fed with battery if needed, but in this converter's DRM application I use the voltage of the receiver itself.

The SA602A is a low-power VHF monolithic double-balanced mixer with input amplifier, on-board oscillator, and voltage regulator. It is intended for high performance, low power communication systems. The guaranteed parameters of the SA602A make this device particularly well suited for cellular radio applications. The mixer is a “Gilbert cell” multiplier configuration which typically provides 18dB of gain at 45MHz. The oscillator will operate to 200MHz. It can be configured as a

crystal oscillator, a tuned tank oscillator, or a buffer
for an external LO. For higher frequencies the LO input may be externally driven. The noise figure at 45MHz is typically less than 5dB. The gain, intercept performance, low-power and noise characteristics make the SA602A a superior choice for high-performance battery operated equipment. It is available in an 8-lead dual in-line plastic package and an 8-lead SO (surface-mount miniature package).

Revision 1.1(June 09)
I have added a low noise transistor (Q1) to amplify the output to a more convenient level, as I noticed that the audio level was just below the ideal level on one PC, whilest on my laptop the level was enough. Remember to set the ideal audio volume level if needed from within your OS. R4 (already existing in rev.v1.0) and C13 gives some additional filtering of the LF signal.

Revision 1.2(Nov 09)
I have noticed that by adding C17 hence limiting the highest frequency responce and amplifying the lower 5...20kC gave additional improvement.
P (trim pot) of 2k5 to allow exact LF output level setting for your soundcard input
Voltage for Q1 now also 6 volt (tapped from IC2)

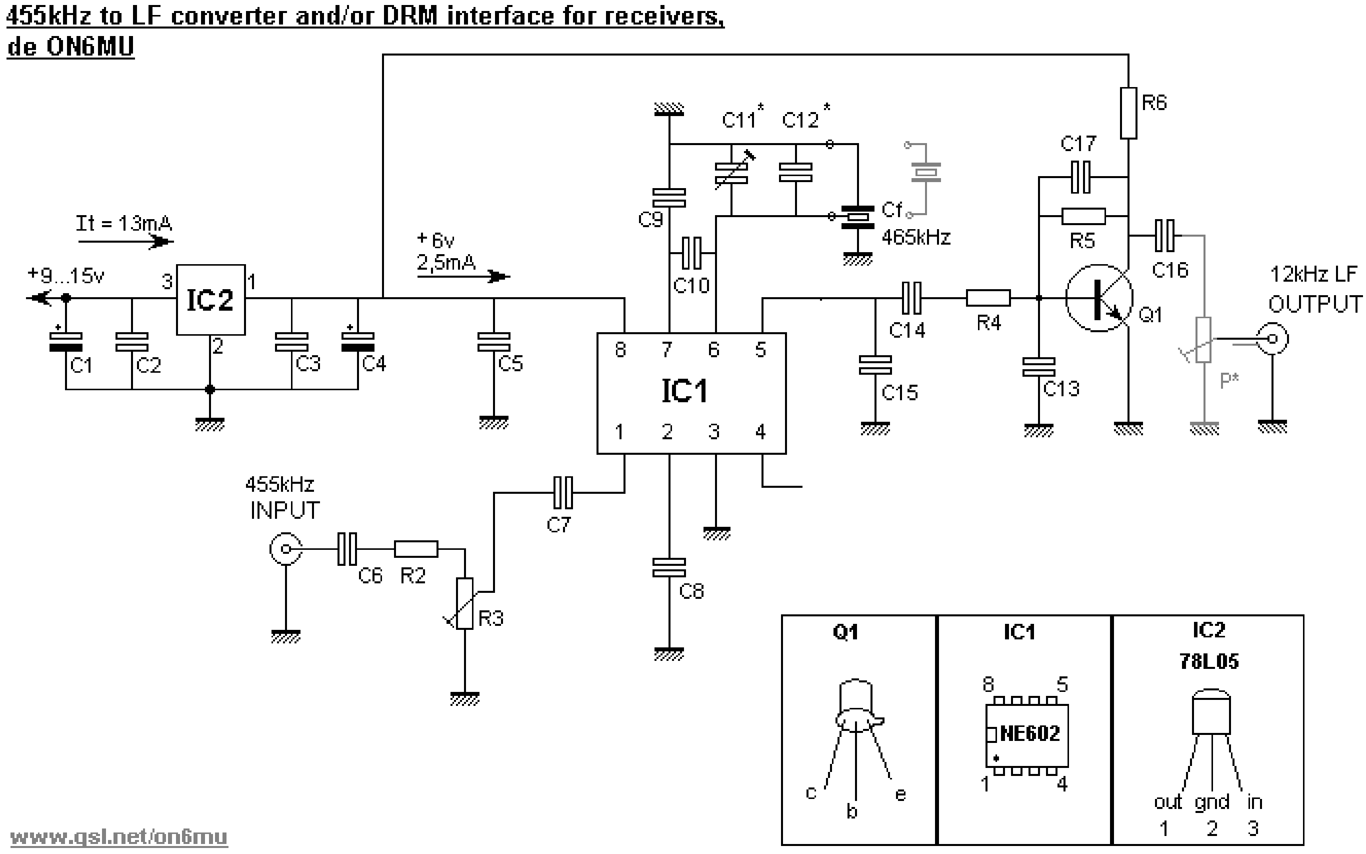
Revision 1.3b(Nov, 21th 09)
C19 & C18 added as it gave a noticable cleaner signal but lower LF output
R7 removed to compensate lower LF output
v1.3b: C18 added

Revision 1.4(Nov 14)
Changed the extractionpoint from the FRG
Some components left out to simplify the project further

RXC0455/0012 455KHz converter technical specifications

- Frequency range from 455kHz...467kHz
- LF/AF out 100...12kHz
- Power supply = 9...18v max
- Total power consumption = 13mA
- Power consumption IC1 = 2,5 mA
- Sensitivity = 0.22uV at 12dB SINAD
- Mixer noise figure = 4,6dB
- Input impedance = 3k
- Output impedance = 1k
- Local oscillator 467kHz
- Frequency stability = +/- 5Hz
- Operating ambient temperature range = -40 to +85°C

RXC0455/0012 SCHEMATIC



PARTS

IC1 = NE602/SA602 or NE612/SA612 (all pin compatible)
IC2 = 78L06
Q1 = BC109,BC107
C1, C4 = 2.2uF/25v
C2, C3 = 100nF
C5 = 470pF
C6 = 100nF(polyester)
C7 = 68nF (polyester)
C8 = 100nF
C9 = 1nF
C10 = 820pF
C11= 100pF trimmer
C12 = 220pF
C13 = 1n5 (poly) *v1.1*
C14 = 220nF (polyester)
C15 = 2n2 (mylar,poly)
C16 = 220nF (poly) *v1.1*
C17 = 120pF *v1.2*
Cf = 465B (ZTB465 kHz, or 470kHz) ceramic filter resonator
R1*= 10k (not specified in the schematic, see text)
R2 = 1k8
R3 = 10k
R4 = 1k
R5 = 100k (*v1.1)*
R6 = 2k2 *(v1.1)*
P* = 2k5 (*v1.2*)

Ceramic resonator:
Cf is a simple 465 khz ceramic filter (3 pin or 2 pin version can be used). These can sometimes be found in a AM/FM transistor radio, old wireless telephones etc.

Ideal would be a quartz version as this offers best stability and accurate resonating frequency of the mixer.
There are many out there that are not exactly on frequency! When using it for DRM the mixing frequency is not critical, so you can use a 470 kHz type too.
If the bandpass is not 12 kHz and the frequency is too high you will need to adjust the mixing frequency Cf by using C11.
If the bandpass does not reach 12kHz because of the mixing frequency being too low you will need to add a capacitor in series with the ceramic resonator Cf, something between 100pF and 300pF. I would recommend starting with 150pF (or use a trimmer).
- ceramic filters can be order here (only EU)

What's DRM

The Digital Radio Mondiale (DRM) purpose is to develop a non-proprietary technical standard for the replacement of analogue AM (Amplitude Modulation) radio with digital radio, also called DRM.

As a replacement for AM the existing channel spacing, medium and long wave 9 kHz and 10 kHz for short wave, is maintained. On medium wave a DRM radio broadcast can provide close to FM audio quality - most people will relate to the poor audio quality of AM music. With DRM the audio quality is primarily determined by the broadcast mode and spectrum occupancy (i.e. radio bandwidth of the DRM signal).

It also the displays the name of the radio station, program text, and automatic tuning to alternative frequencies will make DRM receivers easier to operate. DRM can also transmit multimedia html pages and data.

If you listen to a DRM signal on an ordinary short-wave AM radio then all you will hear is noise. There is no discernible modulation pattern when listening to DRM using a AM demodulator.
DRM Stations recent schedule list

The (DRM) converter explained using a Yaesu FRG-100

There are examples enough around which use another filter by replacing the original LF-H2S with a 12kHz or 15kHz wide filter. This allowed the user to use DRM reception by selecting the AM-narrow mode. The MF output is there tapped from the (hot) connection of VR1002 as seen from the front panel to the IF input of the converter(mixer).
In this modification I use the unused CW-filter connections hence avoiding to remove the top board and soldering/replacing the stock AMN filter. However, both methodes work.
Note: In this example DRM-mode is selected by selecting CW/N mode on your FRG-100.

Calibrating

The converter is best calibrated to fit 12 kHz wide LF output. C11 and C12 primary determines the offset of the base resonating frequency of the 465kHz filter. With a frequency counter you can check the resonating frequency which should be around 467kHz. The converter/mixer outputs 467-455=12kHz wide AF output to be fed to your PC's soundcard input.
Set C11 to get as close as possible to 467kHz. It is possible that C12 need to be changed to if the desired frequency isn't reached.
I have found that it isn't too critical, although calibrating gives the best result. However, it should work as is (set C11 to half way).
Set R3 to the best signal/noise ratio, hence also setting the maximum output of the converter.
Note:
You can add a trim pot of +/- 2k5 at the output of Q1 after C16 to set the ideal output for your soundcard input.

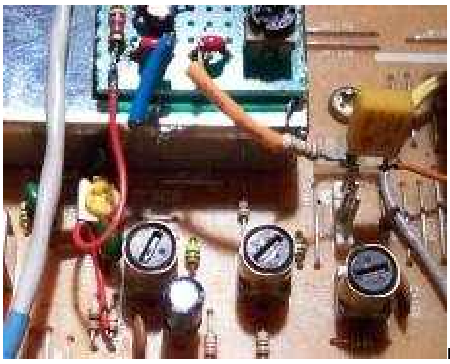
If the bandpass is not 12 kHz and the frequency is too high you will need to adjust the mixing frequency Cf by using C11.

If the bandpass does not reach 12kHz because of the mixing frequency being too low you will need to add a capacitor in series with the ceramic resonator Cf, something between 100pF and 300pF. I would recommend starting with 150pF (or use a trimmer).

Power source voltage

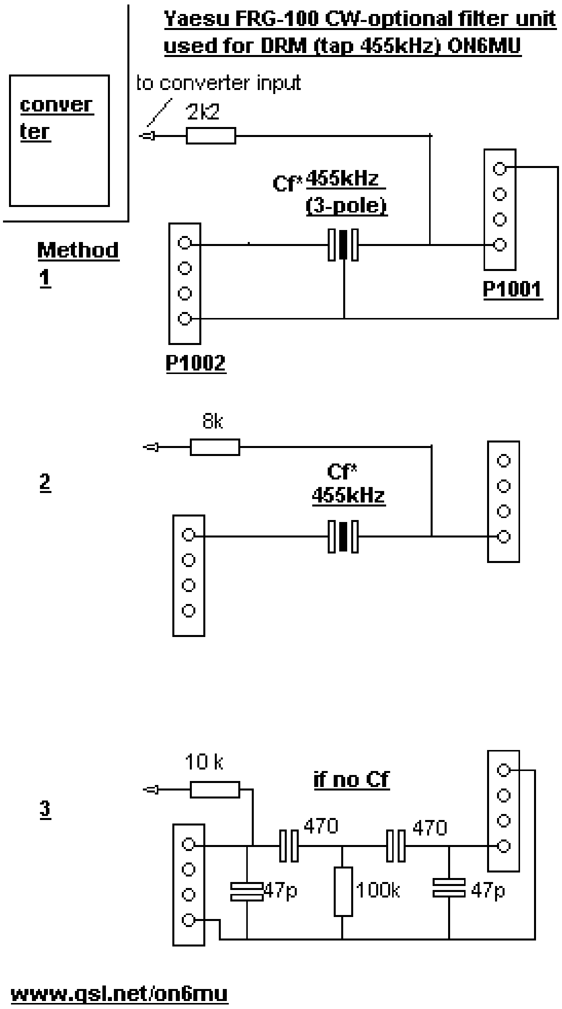
The converter Vcc voltage can be tapped from just about anywhere in the FRG-100. You can use the 12 volt input, or tap from the 9volts running allover the board. Tap often used is R1074 (closest to the front to the UB connection of the mixer board) where you find +9volt.
Any voltage from 8 to 18 volts can be fed as the converter uses a 78L06.

Using the CW/N optional filter connections


red wire is the +9v tapped from R1074, 47k resistor and ceramic filter is connected to the CW/N filter connector to get MF

It is perfectly possible to use the CW/N filter connections of the FRG-100 to tap the MF 455kHz...465Khz to feed it to our converter/mixer.

Use a 455kHz filter of 12...50kHz (often found in those old FM transistor radios etc.). This is soldered between pin 1 (top one) of CW/N filter connector P1002 and pin 4 of P1001 (bottom pin). A 47k resistor from P1002 pin 1 is fed to the input of the converter.
If you can not find such a ceramic filter (doubt it) you can replace it by a few caps (this is not a drop-in replacement, but workable enough to use for DRM with good signals till better is found).



Note: DRM-mode is selected by selecting CW/N mode.

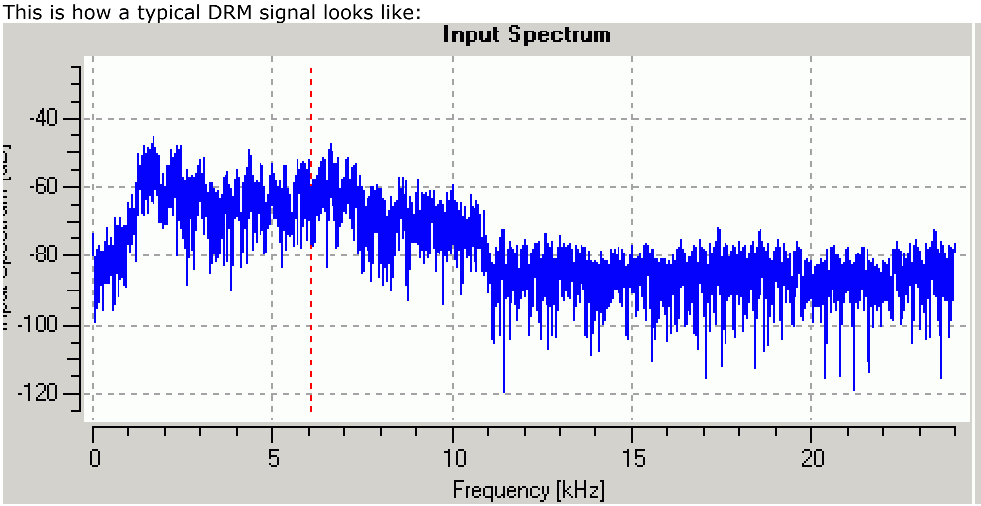
I soldered several of the converter grounds to the VFO chassis (approx. middle of the picture)
You can see the yellow/greenish 455kHz 20kc ceramic filter (between the converter and the FM-unit)
On the right side you can see my homemade FM-module based upon the Yaesu schematic found in the manual.

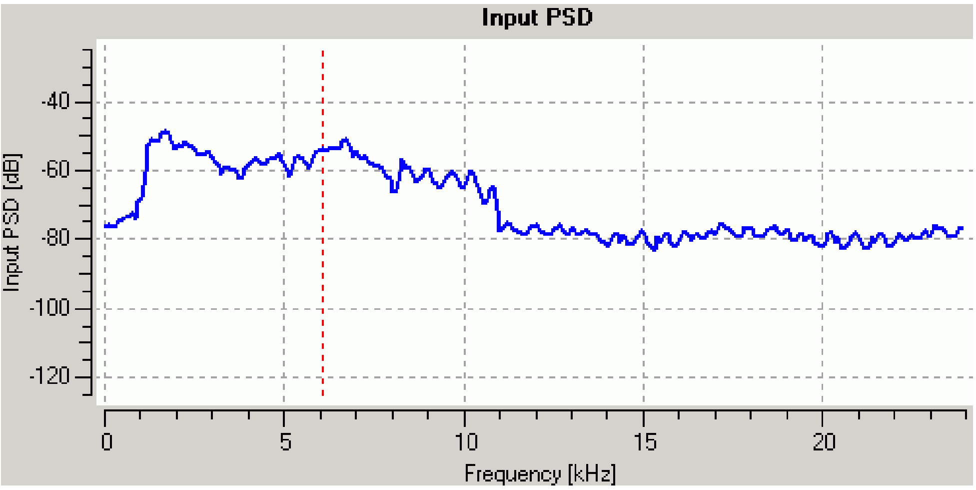
Output/tuning/setting

The output of the converter is fed to your soundcard using a female connector (on the backside of the receiver). I drilled a hole at the back of the FRG-100 to mount a 3.5mm female connector.
Use shielded wire to connect the converter to the connector.
R3 sets the maximum level of the MF signal supplied, hence adjusting R3 can improve the signal-to-noise ratio depending on the input sensitivity of your soundcard and/or do to the MF voltage

input. Set R3 to 80% to start with. Adjust the adjustment on the mixer board for a DRM-signal of approximately 50mV RMS.

This is how a typical DRM signal looks like:





- Connect the decoder software to the 12 kHz IF output of the converter.
- Set the input volume of your PC properly.
- Set your FRG-100 to CW/N mode.
- Tune to a good DRM signal (3995,5955,6095,13810Khz...).
  Note: I have found that by tuning +/- 2Kc of the DRM signal, the quality improves. Possible reason could be the sound card timing accuracy, or the LO frequency is not exact. Experiment!
  Note: To decode a DRM signal, the signal strength needs to be high and the S/N ratio has to be at least above 12dB
- Once you here the software decoding the DRM-signal you can further tweak the settings as explained above. And, the software itself has several settings that can improve the reception/decoding capabilities.

Some examples of decoded DRM signals using this converter/mixer and a Yaesu FRG100

- **Example 1a of a decoded DRM signal** - ideal reception conditions!
- **Example 1b of a decoded DRM signal** - medium ideal reception conditions!
- **Example 2 of a decoded DRM signal** - medium ideal reception conditions!
- **Example 3 of a decoded DRM signal** - bad reception conditions!

Software

DRM

Dream
http://drm.sourceforge.net
Dream - to decode DRM signals: Dream v1.16 compiled version

The necessary Qt runtime library "qt-mt230nc.dll" can be downloaded at:
http://prdownloads.sourceforge.net/netclipboard/qt-mt230nc.dll?download

Optional download: AMSchedule.ini
Get the current shortwave broadcasting schedule for AM stations from:
http://drm.sourceforge.net/download/AMSchedule.zip

Other DRM software: http://home.arcor.de/carsten.knuetter/drm.htm
SoDiRa
Free Software Radio (also good for DRM)
Tip: choose in Config->Receiver->Type: DSR30
http://www.dsp4swls.de/sodira/sodiraeng.html

WinRadio
Commercial DRM Demodulator/Decoder for Windows 2000, XP and Vista
Tip: Choose general-purpose DRM Software Radio (DRM demodulator/decoder for third-party receivers)
http://www.winradio.com/home/download-drm-2.htm

SDR

MDSR
MDSR is a powerful and free SDR capabale package.
homepage

HDSDR Homepage
HDSDR is a freeware Software Defined Radio (SDR) program for Microsoft Windows 2000/XP/Vista/7/8.
download
Typical applications are Radio listening, Ham Radio, SWL, Radio Astronomy, NDB-hunting and Spectrum analysis.
HDSDR (former WinradHD) is an advanced version of Winrad, written by Alberto di Bene (I2PHD).

SDRadio:
SSB, CW and AM demodulator: http://www.sdradio.eu/sdradio/
By I2PHD and IK2CZL, practic skin, made for für I/Q direct mixing concepts,
demodulates also by set an offset of middle frequency
to 12 kHz single IF very well. Can handle 40kHz+

G8JCFSDR:
Software defined radio using MF: http://www.g8jcf.dyndns.org/g8jcfsdr/
By G8JCF, good AM, better SSB and CW demodulator, also software AGC.
Several filter and noise reduction equipment. Also recorder mode supported.
http://www.g8jcf.dyndns.org/g8jcfsdr/

SM6LKM:
A Soundcard Based SAQ VLF Receiver:
http://web.telia.com/~u33233109/saqrx/saqrx.html

SoDiRa
Free Software Radio (also good for DRM)
http://www.dsp4swls.de/sodira/sodiraeng.html

SDRadio
I2PHD's SDRadio can be downloaded from here:
http://www.sdradio.org/

IFDSP
IK2CZL's IFDSP can be downloaded from here:
http://www.detomasi.it/en/project.html

DRM reception with the Yaesu FT-817

We use the optional CW or SSB Filter slot in the main unit. You must have this slot free (no optional filter) for using DRM on this radio.
The 455 KHz Signal for the DRM mixer can be easy taken from the first pin (from right) of J21 connector and connect the ground of cable to the second pin.
Now put a 455kc resonator between the first right pin of J20 and the first right pin of J21. Note:

You can use simular like used in the FRG-100 please see fig2.
If you do not have a 455kc resonator then a capacitor of +/- 120 pf will be do, but you loose the agc advantages.

Switch on the rig and enter in the Menu System (press and hold the [F] key for on second) and choose Menu Item 38 [OP FILTER] setting mode CW.

You can activate now the DRM reception using the function NAR of the operation menu and setting CW MODE.

DRM reception with the Yaesu FT-897

Look for the slots for optional CW or SSB filter (backside, left) It's labelled: J24 and J23.
Bridge the left two pins of J24 – so the software will use this slot as if the SSB filter is installed.
Put a 455kc resonator between the right pin of J24 and the right pin of J23. The third pin of J23 is connected to ground.
If you do not have a 455kc resonator then a capacitor of +/- 120 pf will be do, but you loose the agc advantages

Connect the DRM converter to the two right pins of J23 (ground and 455 kHz IF in).
I tapped 13 volts from the 8 volt voltage regulator (see on photo lower right corner). This connection is in consistency with the power on/off state of the rig.
For using the converter you have to enable the 2.3 kHz optional Filter setting in Menu (that's the reason for the J24 jumper)

drm using a FT-897

Tips

* This converter can also be used to feed a LF-amplifier (listen to signals unfiltered)
* Works with some software defined radio (SDR) programs, like SDRadio from I2PHD!
* Use it to analyse wide band spectrum
* Modify the converter to allow even wider bandwidth by changing the resonating ceramic filter.
* Can of course be used by any receiver that has a 455kHz MF you can tap.

More about the SA602 (NE602,SA612,NE612,SA162) in this project

The SA602A is a Gilbert cell, an oscillator/buffer, and a temperature compensated bias network as shown in the equivalent circuit. The Gilbert cell is a differential amplifier (Pins 1 and 2) which

drives a balanced switching cell. The differential input stage provides gain and determines the noise figure and signal handling performance of the system.
The SA602A is designed for optimum low power performance. When used with the SA604 as a 45MHz cellular radio second IF and demodulator, the SA602A is capable of receiving -119dBm signals with a 12dB S/N ratio. Third-order intercept is typically -13dBm (that is approximately +5dBm output intercept because of the RF gain).
Besides excellent low power performance well into VHF, the SA602A is designed to be flexible. The input, RF mixer output and oscillator ports can support a variety of configurations provided the designer understands certain constraints, which are explained here.

[50Mc converter de ON6MU]
[SDRadio]
[FRG-100 audio improvement]
[Dream v1.16 compiled version]
[Example of a decoded DRM signal]

Technical graphs:

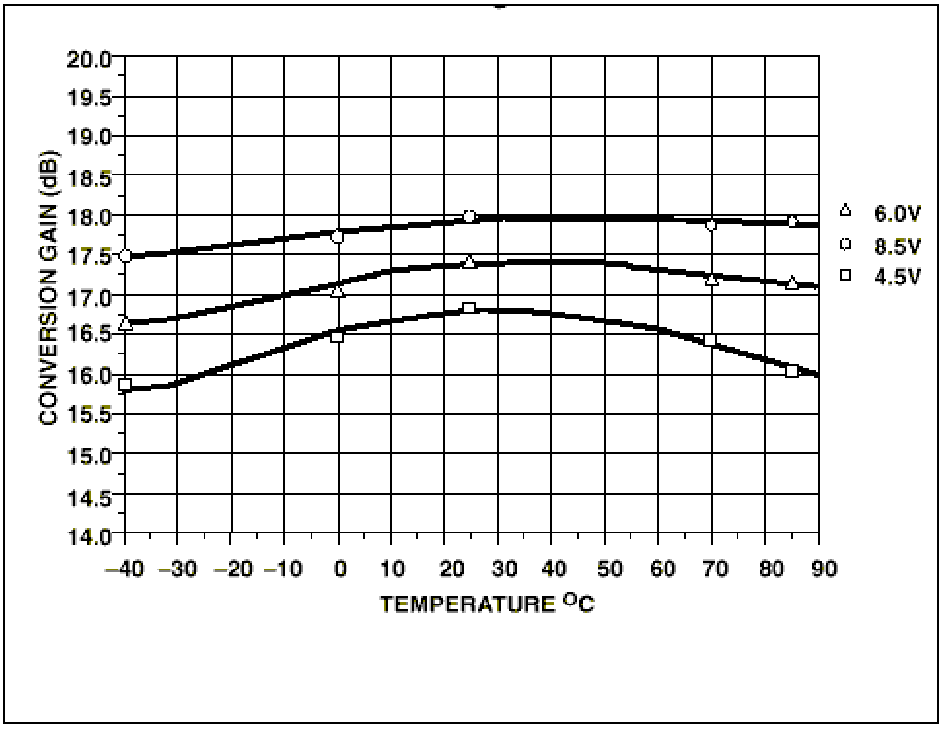


Figure 3 . Conversion Gain vs Supply Voltage

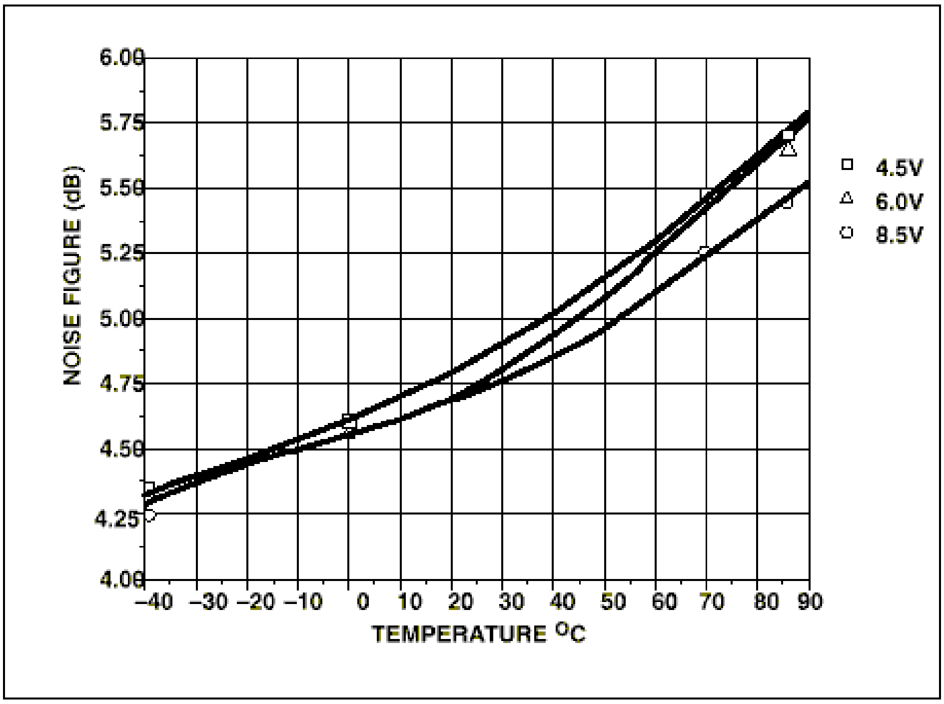
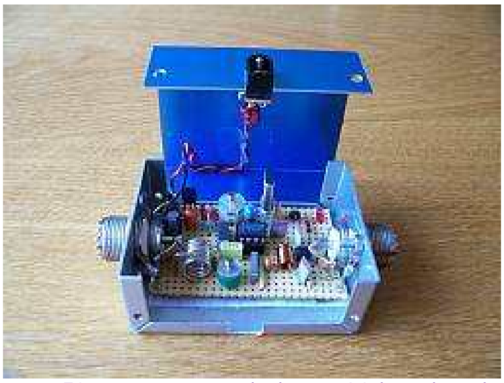


Figure 5. Noise Figure

Please also look at our [Digital Analog Demodulation Project](#) (DADP, VE7DXW) that explains in high detail how to use it for the Yaesu FT-817 and simular transceivers

More about these mods:

Youtube:
This is how Tonino IZ6QTX made it and how he is using it:
http://www.youtube.com/watch?v=VoKhKqP2duM
http://www.youtube.com/watch?v=5MvFH9X5kpU
Thank you Tonino!



Please take a look at my 50MHz converter which is ALSO based on the SA/NE 602 mixer!

My E-mail

Note: if you want to commercialise, publish or distribute this project then you need to ask permission to do so.

Attention! The modification will be done at your own risk!

[home]

[mail] [shack] [homebrew] [software] [satellite]
[haminfo] [mods]

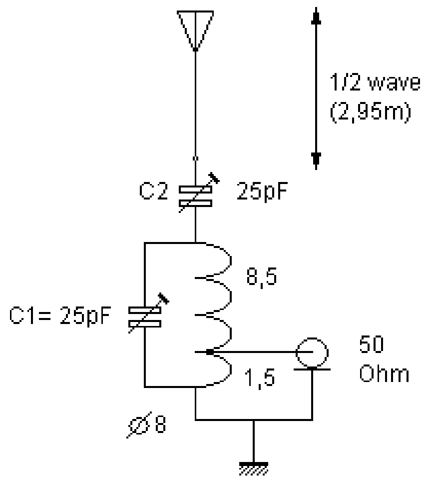
Back to ON6MU **Homepage**

ON6MU

VHF 1/2wave vertical antenna for the 6-meterband (50 Mhz)
RE-A50V12

By Guy, de ON6MU

Schematic fig1



1/2 wave antenna principle

A much better type of antenna then a simple quatre wave and that has more gain is the 1/2 wavelength vertical. We know that the impedance of the 1/2 dipole is 70 Ohms when we attach the coax in the middle, but what if we were to attach our coax directly to the end? The impedance at this point is high, very high, so we must make a matching device to match the antennas impedance to the 50 Ohm coax. What would happen if we did not use this matching device? Well...you would know that this would result in a very very high SWR.
The bandwidth of these antennas are good, they can easily span the entire 50Mc band and more with a low SWR. But, in this design, the bandwidth is limited to approx. 600kc (without re-tuning C1 or C2). This allows you to tweak the antenna to your desired band and avoid interference and reduce intermodulation.
The antenna and ground are connected across the tuned circuit while a 50-ohm coaxial cable is connected to taps on the inductor. The tuned circuit presents a high impedance to the antenna and the tapped inductor steps this impedance down to 50 ohms. Adjusting the tuning capacitor tunes out slight reactance variation if the antenna is not an exact electrical half-wavelength.

Parts list

- 4 pieces of 1 meter alu or copper tubing:
  - one 18 mm diameter
  - one 15 mm diameter
  - one 12 mm diameter
  - one 10 or 8 mm diameter
- 1 female PL 259 chassis
- some cul wire (isolated wire like from a transformer etc.) of 0,8 mm thick
- a coil holder of 8 mm diameter
- two 25pF regulable capacitors
- A robust PVC box of approx 30x50x18 mm and 2mm or more thick
- a piece of hard insulating material that snuggly fits inside the base tube, like:
  fyberglass, nylon, hard pvc, hard wood, bamboo etc... as long as it's very strong, stress and weather resistant.
- and a few innox hose clamps

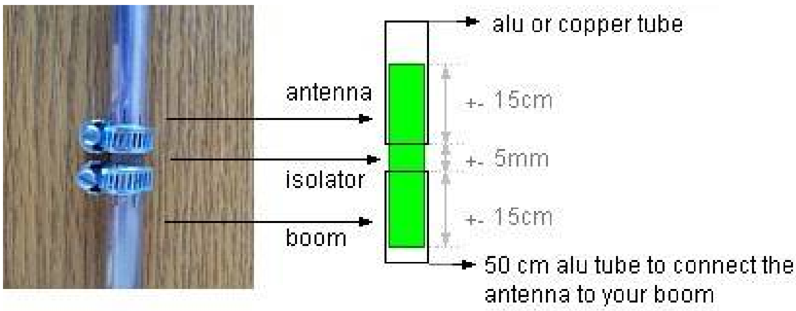
Note: there are many ways to build your antenna and I'm sure some can come up with better mechanical designs then described here although the design and material used here is cheap and easy to find. Also, the diameters of the tubing described here is not too critical.

Links of interest:

The antenna

- Construction:
  The vertical itself is constructed out of four overlapping sections of aluminum tube whose sizes are given.

  - saw the 1 meter 18 mm alu tube in half. One part (50 cm) will be used as a boom and the other as the first part (also 50cm) of the antenna.
  - saw some grooves (approx 1,5 cm) in both halves of the tube to allow a hose clamp to tighten everything up.
  - same goes for the other tubes that fits inside eachother. All tubes are firmly fixed together by using hose clamps.
  - Measure from the base up 2,95 meters. You can alwyas tune the antenna to its best SWR by sliding the top tube in or out.



  - saw a piece of that hard insulating material of your choice and fit it 10 cm in the antenna and boom part and leave a gap of 3 mm between them.
  - hammer down one end of each of the 3 radials (3 x 22 cm) so it becomes a bit flatten. This will make things easier to screw tight with the hose clamp. These radials are fitted on the boom section.

- The little black box:
  
  Here is where all the secrets are stored HI. I used a little plastic box where I placed the LC-circuit and the PL connector.
  I also drilled two little holes where you can regulate the two capacitors with an little isolated screwdriver. Afterwards you can seal the holes up to prevent moisture from entering the box.

- The LC tank-circuit:
  - Wind 10 turns of 0,8mm cul wire around the 8mm coil holder and make a tap at 1,5 turns. There is no spacing between the windings.
  - The smallest part (the "cold side" 1,5 turns) of the coil is where your centre part of the connecor/coax is connected to. The above schematic shows how.

- As you can see there are two wires comming out of the box (which contains the LC): one for the antenna and the other for the ground (being the connecting boom piece).
  

- Connect the wires accordingly and be sure to seal everything up.

- Tuning:
  - Get your old (t)rusty SWR-meter and and some 50 Ohms coax and connect your transceiver to it.
  - Set the two capacitors to halfway to start with.
  - Mount your antenna temporary 1,5 meters from the ground for the first tests and measure the antenna length (the boom piece NOT included) at 2,95 meters and try to ground the boom.
  - Find a CLEAR frequency and set your transceiver to MINIMUM possible power and use a carrier type modulation (CW, AM, FM).
  - Tune C1, which is the most important and critical capacitor, till the SWR gets a s low as possible on your desired centre frequency (51 Mc)
  - Then tune C2 till the SWR is even more lowered or even 1:1.
  - Repeat the last two steps at location if needed
  - Fine tuning your antenna can be done by sliding the tubes in or out. Sometimes when your place your antenna higher or when the antenna has obstacles in its proximity the SWR can vary from the one you noted first. Raising or lowering the length of the antenna should fix it.

Highlighted

Specifications ON6MU Vertical Antenna RE-A50V12

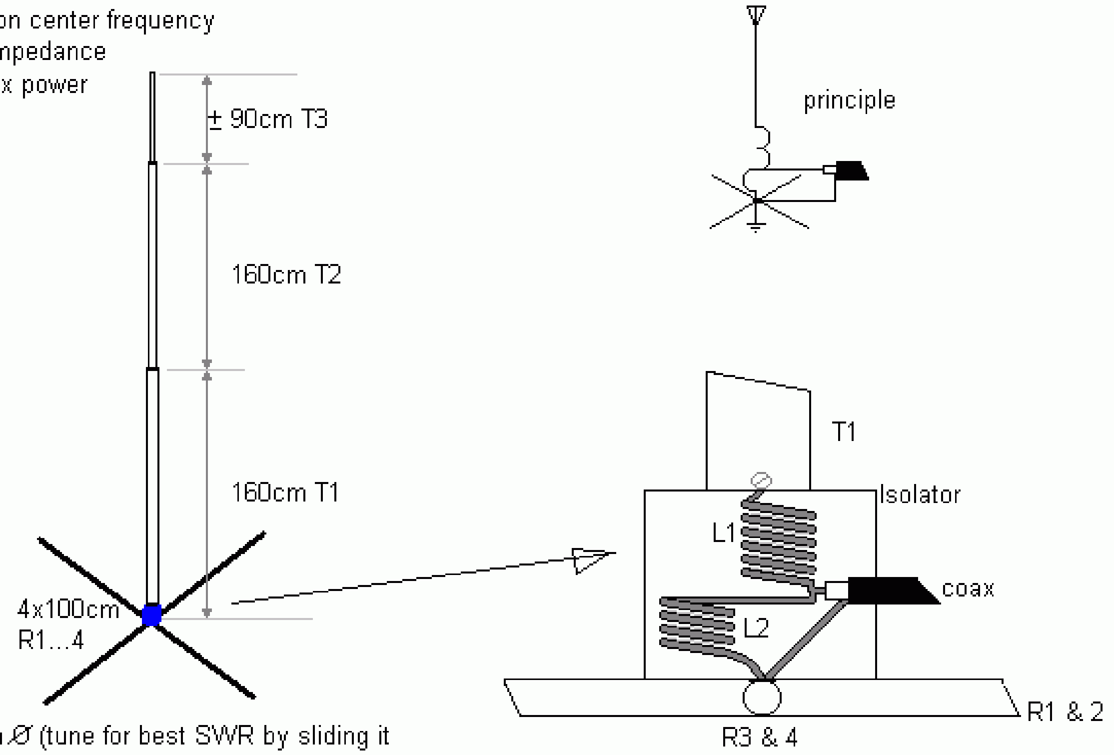
- Total length (including the 50cm mounting boom piece): 3,5m (2,95m effective)
- centre frequency: 51 Mhz
- bandwidth: 2 Mhz
- maximum tunable frequency range: 49...53 MHz+-
- impedance: 50 Ohms
- Gain: 3,6 dBi
- Maximum power using the components described: 20 watt
- NO counterpoise or radials needed if the boom is grounded or the boom length is >= 1,5m
- DC grounded (no static buildup)
- Height: 2,95m
- If needed, it can be disassembled into a very small bundle no longer than the longest element.

Be sure to seal everything up to avoid moisture, corrosion etc...

5/8 vertical groundplane antenna for 50MHz RE-A50V58

5/8 vertical groundplane antenna for 50 MHz,

Omnidirectional pattern
4.7dBi gain
2 MHz Bandwidth at 1.5 SWR
1:1 SWR on center frequency
50 OHm impedance
200 W max power



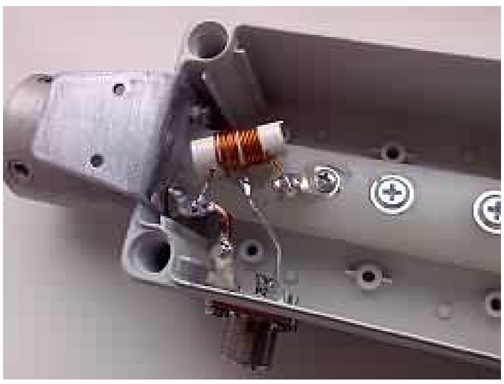
T3 = 10mm Ø (tune for best SWR by sliding it in or out T2)
T2 = 15mm Ø
T3 = 20mm Ø
R1...4= four tubes of 1 meter or 2 tubes of 2 meter crossed Ø 8mm or Ø 10mm
All alu tubing

L1 = 7 t 0.8mm, coil Ø 10mm
L2 = 5 t 0.8mm, coil Ø 10mm

de ON6MU

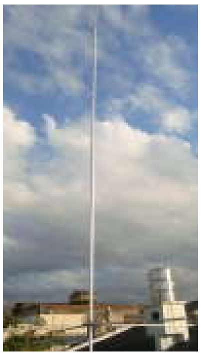
Note: If using a grounded boom, you can leave out the radials R1...R4 or shorten them to approx. 4x30cm

This is how Greg, **SP5LGN** constructed my 5/8 lambda 6-meter GP antenna:




Click to enlarge
Many thanks Greg!

How Horacio LU9DFN made it:

Click to enlarge
Many thanks Horacio!

SWR:
You can fine-tune the SWR to peak in the bandsection you are planning to use the 5/8 groundplane antenna by:

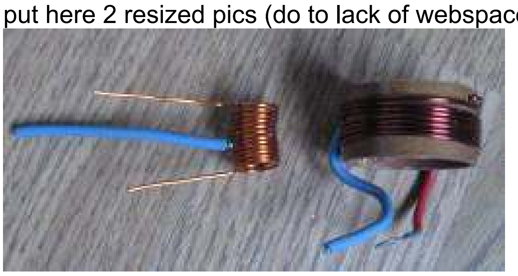
- \- shorten or lengten the radiating element (vertical section)
- \- shorten the radials
- \- experiment with the coil spacing

Today's specials:

ON6MU Homebrew projects
Radioamateur related projects

ON6MU Ham mods
Modifications of transceivers

PA3BEN sent me a lot of pics on how to convert an old CB antenna using my schematic (shown here above) for 50Mc! I've put here 2 resized pics (do to lack of webspace, sorry):



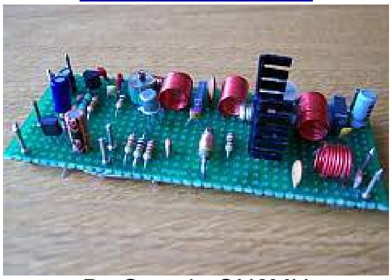
Thanks Ben!

Please take a look at my 50mc wide-spaced yagi antenna

ON6MU
Home

ON6MU

1Watt AM(cw) Transmitter for the 10 meterband RE-TX1HF10



By Guy, de ON6MU

Revision v1.6 (Jan 2012)

About the 1watt AM/CW 10-meter band transmitter RE-TX1HF10

In this project, you will make a simple 3-stage low-power broadcast-type circuit, using a crystal oscillator integrated circuit and an a collector modulated AM oscillator with amplifier. You can connect the circuit to the an electred microphone or amplified dynamic microphone. Using an electred microphone is shown (in gray) in the diagram below. (no amplified dynamic microphone has a to low output voltage to work. at least 100mv is needed). You could also add a LF preamp stage of one transistor to allow connecting a dynamic microphone directly.

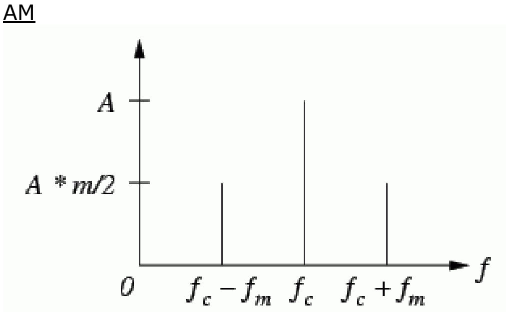
You'll see that you can receive the signal through the air with almost any AM radio receiver. Although the circuits used in radio stations for AM receiving are far more complicated, this nevertheless gives a basic idea of the concept behind a principle transmitter. Plus it is a lot of fun when you actually have it working!
Remember that transmitting on the 10 meter band you'll need a valid radioamateur license!!

A wide range of different circuits have been used for AM, but one of the simplest circuits uses collector modulation applied via (for example) a transformer, while it is perfectly possible to create good designs using solid-state electronics as I applied here (T1 BC557).

The transmitter is build as a Colpitts Oscillator with a BSX20 transistor. HF-output of the oscillator is approx. 50 mW, depending on the supply voltage of 8 to 16 Volts. This is amplified by the BD135 and brings the power up to approx. 1 watt @ 14volts with 100% modumation. The transmit frequency is stabilized with the 28Mhz crystal. A slight detuning of approx 1kc is possible when using a 120pF trimmer capacitor for C8. The oscillator signal is taken from the collector of T2 and guided to the input of T3 which output is lead via an L-filter and low-pass PII filter circuit cleaning up the signal pretty good and ensuring spectral purity. The oscillator is keyed by T1 and the morse key (S). By keying the morse-key T1 is not been used for modulation and is biased, hence lets T2 freely oscillate.

The oscillator uses a single coil and crystal. The coil is tuned to the output frequency, which may correspond to the crystal frequency, or a harmonic.

AM



The resulting AM spectrum using sinusoidal carrier and modulating waveforms.

Amplitude Modulation (AM) is a process in which the amplitude of a radio frequency current is made to vary and modify by impressing an audio frequency current on it.
This was the first type of modulation used for communicating signals from one point to another and is still the simplest to

understand.
A radio frequency current has a constant amplitude in absence of modulation and this constant amplitude RF carries no information, i.e. no audio intelligence and is of no use to radio telephone (voice communication), but has application in morse code communication.
In its basic form, amplitude modulation produces a signal with power concentrated at the carrier frequency and in two adjacent sidebands. Each sideband is equal in bandwidth to that of the modulating signal and is a mirror image of the other. Thus, most of the power output by an AM transmitter is effectively wasted: half the power is concentrated at the carrier frequency, which carries no useful information (beyond the fact that a signal is present); the remaining power is split between two identical sidebands, only one of which is needed.

CW
CW is the simplest form of modulation. The output of the transmitter is switched on and off, typically to form the characters of the Morse code.
CW transmitters are simple and inexpensive, and the transmitted CW signal doesn't occupy much frequency space (usually less than 500 Hz). However, the CW signals will be difficult to hear on a normal receiver; you'll just hear the faint quieting of the background noise as the CW signals are transmitted. To overcome this problem, shortwave and ham radio receivers include a beat frequency oscillator (BFO) circuit. The BFO circuit produces an internally-generated second carrier that "beats" against the received CW signal, producing a tone that turns on and off in step with the received CW signal. This is how Morse code signals are received on shortwave.

Although this design is primarely designed for AM, it can be used for CW by keying S and so powering the oscillator. You can remove the modulation section all together if you use it only for CW. The amplifier (T3) is always fed with 12...16 volts Vcc and doesn't need to be switch off together with the oscillator.

If you only gonna use this transmitter for CW, then you can leave out the modulater section (T1). But remember that there is a 3 volt difference between Vcc and the voltage on the oscillator. So with modulator 12 Vcc is 9 volts on T2, without T1 ofcourse 12v also.

RF Oscillator
Is been carried out by T2 (NPN BSX20). This is the stage where the carrier frequency intended to be used is generated by means of Crystal Oscillator Circuitry or capacitance-inductance based Variable Frequency Oscillator (VFO). The RF oscillator is designed to have frequency stability (Xtal) and power delivered from it is of little importance, although it delivers 50mW@14v , hence can be operated with low voltage power supply with no dissipation of heat.

You could add a switch (not recommended, but if you do, use very short connections) to select different Xtal's (frequencies). You could also use a more effective diode-based switch I've build here. This hasn't got the problems with longer connections at all.

Injection of signal of an external tuneable oscillator to trigger T2 to oscillate is possible by removing the Xtal and connecting C8 to your oscillator.

Filter
RF power amplification is also done here and this stage is coupled to the antenna system through antenna impedance matching circuitry (L1/L3,C16,C18). Care is taken at this stage so that no harmonic frequency is generated which will cause interference in adjacent band (splatter) on other bands (L3/L4,C16...C20). This 3-element L-type narrow bandpass filter circuit and a lowpass filter for the desired frequency cleans out any remaining harmonic signals very efficiently.

Modulator
Is done by T1 (PNP BC557). Audio information is impressed upon the carrier frequency at this stage. Do to selective components circuits (R10, R11, C25, C3, C4, C5, C6, C7) the voice component frequencies are enhanced, whilest others are suppressed (bandwidth +- 3kc/side) keeping it approx. between HAM-radio specs.
Collector modulation is applied here. The efficiency isn't 100%, but it does keep the simplicity of the design intact.

Why over modulation is not desirable?..
Over modulation is not desirable, i.e. modulation should not exceed 100 %, because if modulation exceeds 100 % there is an interval during the audio cycle when the RF carrier is removed completely from the air thus producing distortion in the transmission.

Housing/shielding
The whole circuit needs to be mounted in an all-metal/aluminum case. If you're unable to obtain an all-metal case, then use a roll of self-sticking aluminum tape (available from your hardware store) or PVC box painted with graphite paint. Just make sure that all individual pieces of aluminum-tape (or the graphite paint) are conducting with each other. Works fine.

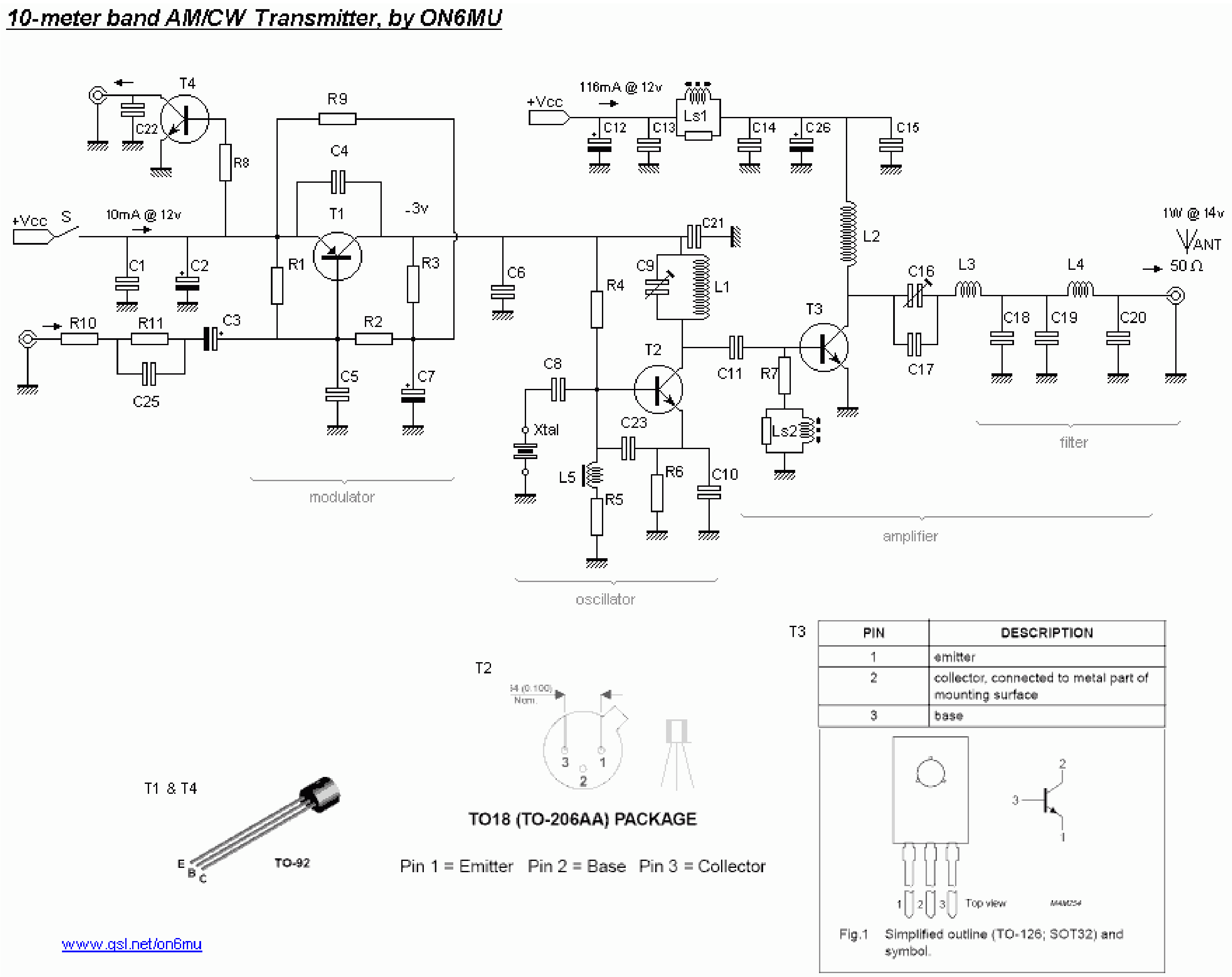
More power
You can connect the output to my power MOSFET based 10-meterband power amplifier wich should cranck up the power to approx. 6 watt. You'll find it here.

Mute: Use the transmitter with your receiver
If you put a relay, or better a transistor switch to mute your receiver (if equiped) you can easily make a QSO HI. A simple BC338, 2N2222 at pin a" with the base biased with a 100k resistor, emmitor at the gnd and the collector fed to your receiver's mute input works fine. Or you can use a 12v relay... Every time you PTT the transistor (or when using a relay, the switch) is "shortened" between the ground, hence muting your receiver (again; if your receiver has mute capabilities). This is shown in the diagram below.

Specifications

- Peak Frequency range: 28Mc...30Mc
- Output RF PEP power: approx. 1W@14v @85% modulation
- AM modulated (CW if keyed)
- Adjustable output impedance to 50 Ohms
- Band-pass type harmonic L-filter + low-pass PII filter
- Usable voltages: Vcc 10 - 16 volts
- Average current: I= 120mA
- Xtal oscillator, 28.xxx Xtal
- Adjustable frequency of 2Kc (if C8 is replaced with a 120pF trimmer)
- Injectable with external oscillator *see text
- LF input +/- 100mV @ 1K

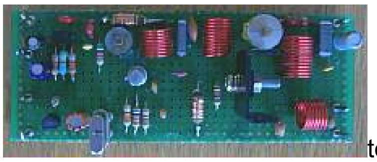
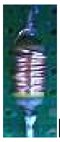
Schematic 10-meter band AM transmitter: fig1



Parts list 10-meterband AM / CW transmitter

- T1 BC557 (*modulator*)
- T2 BSX20 *oscillator* (2N2219. BC109 works also, but little less power)
- T3 BD135 *amplifier* (with heat sink isolated from the transistor)
- T4 2N2222, BC338 *mute*
- C1 = 100nF
- C2 = 47uF/16v (tantal)
- C3 = 2.2 uF/50v (changed in rev v1.5)
- C4 = 33nF (polyester) (changed in rev1.5)
- C5 = 10nF (polyester)
- C6 = 47nF (changed in rev1.5)
- C7 = 4.7uF/50v
- C8 = 10nF
- C9 = 0...22pF (60pf for 27Mc)
- C10 = 120pF
- C11 = 56pF
- C12 = 470uF/16v
- C13 = 100nF
- C14 = 47nF
- C15 = 470pF
- C16 = 6...40pF
- C17 = 12pF
- C18 = 120pF
- C19 = 56pF
- C20 = 100pF
- C21 = 470pF
- C22 = 100nF
- C23 = 10pF*(added in revision v1.2)
- C25 = 0,47uF (polyester, added in rev1.5)
- C26 = 47uF tantal (added in rev1.6)
- R1 3k9
- R2 3k9
- R3 4k7 (*rev1.6)
- R4 6k8 (*rev1.6)
- R5 1k2
- R6 220

- R7 12
- R8 100k
- R9 4k7* (added in revision 1.4)
- R10 270 (added in rev1.5)
- R11 390 (added in rev1.5)
- Ls1, Ls2 = 470 1/2 watt carbon!, 0,2 Cul turned 3 times over the entire length of the resistor (or +/- 2.7uH inductor) or use ferite bead
  note: you can also use a ferrite core of 3...4mm instead of a carbon resistor
- L1 = 0.8mm insulated copper wire, 9 turns close together, 7mm inside diameter (or 7 turns of 0.8mm wire around 8mm support (it should correspond to about 250nH))
- L2 = 0.8mm insulated copper wire, 12 turns close together, 6mm inside diameter
- L3 = 0.8mm insulated copper wire, 13 turns close together, 7mm inside diameter
- L4 = 0.8mm insulated copper wire, 7 turns close together, 7mm inside diameter
- L5 = 100uH inductor (*added in revision 1.3)
- Xtal fundamental frequency or overtone for your desired frequency (28...30Mc)
- C4, C5, C6, C25 polyester film capacitors
- (L6 and C24 removed in rev1.6)


top view

Ls1,Ls2,Ls3

Revision 1.2
C21 added to prevent the oscillator from oscillating at 2e harmonic when not connected to the amp-stage. If the oscillator is coupled/connected (via C11) with the input stage of the amplifier as designed (even if the amp stage is not powered) 2e harmonic oscillations are prevented even without C21.
To resolve this issue (in any situation) C21 has been added.
C5 was missing from the partslist
R2,R3,R4 had slight diviated values from standard available resistors (thanks Medard from Switserland!)
Revision 1.3
To improve T2 BIAS: R5 was 2k2, now 1k2. L5 added (100uH)
To improve T1 BIAS: R1 was 4k7, now 3k9
C12 changed
Revision 1.4
Ls1 (former between C6 and C7) is replaced by 100uH inductor
R9 added to improve modulation
Revision 1.5 (May 2009)
R10, R11, C25 added, and C3,C4,C6,C24 changed values: to improve linearity

Note:
Always use a dummy load for testing and adjusting the transmitter!!!

Salvatore Polito made the the 1 watt 27/28mc transmitter together with the 5 watt amplifer:

Antenna's

It's important to use a correct designed antenna according to band you would like to operate, or at least use a good antenna tuner to match the antenna (protecting your transmitter and proventing harmonics/interference...). Several examples can be found on my website and all across the Web. A dipole is always a good alternative (total length = 150/freq - 5%).
The performance (distance relative to you RF power) of your antenna is as importent (if not more) as the RF power you transmit! A dummy load gives also a perfect 1:1 SWR, but you wont get any farther then the street you live in HI. Finally, athmospheric conditions (D-,E-,F-layers depending on the frequency you're using) is equally important to be able to make DX QSO's.

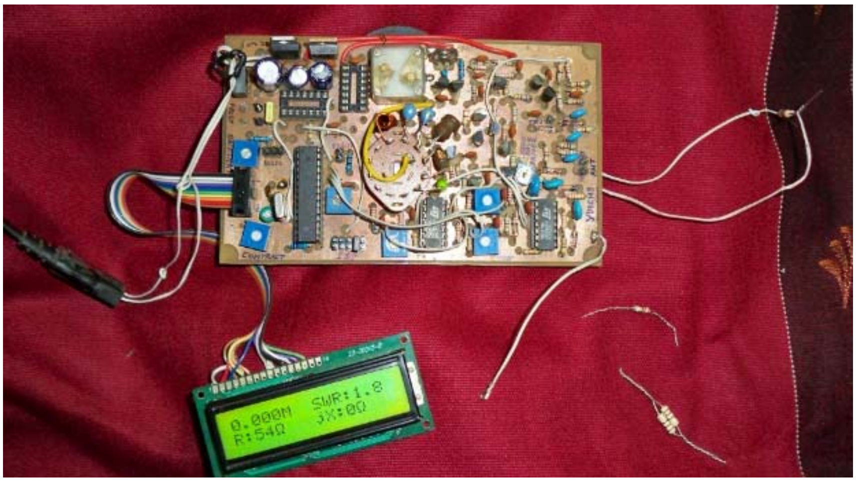
Remember that transmitting on 10 meter band (or building and using the transmitter) needs a valid radioamateur license!

12 meterband AM / CW transmitter project

ON6MU
Home

Homebrew Poor Man Antenna Analyzer (HPMAA)

Started From The End of August, 2010
Written by Cholis Safrudin, YD1CHS
http://yd1chs.wordpress.com



1. Abstract

The need of a useful tool for measuring antenna impedance and its resonance frequency is a must for an amateur radio who wants get an optimum performance. Unfortunately, there are many unlucky HAM who could not spend much money for it. In Indonesia a medium quality one costs about four million rupiahs (or US$400), such a big cash for us. One solution that could solve this problem is homebrewing it using locally available components which would be cost only about US$30.

There were many techniques appeared in the net, however I adopted such a simple technique in my week end project, i.e. Vector Analysis technique. Several HAMs had been worked for this technique, including VK5JST, UT2FW, ZL2PD and RX3ADU. It occupies a broadband regulated amplitude oscillator, a set of diode detector and a microcontroller for its calculation. According to those references, I decided to mixed their designs in order to adapt locally available components at my town as well as reduce its development cost. Several modifications had been done, they were transistor types on VFO block, Prescaler circuit on frequency counter block and an ATMEGA-8 microcontroler on MCU block. Furthermore, several features had been added, such as “Debug Mode” that switch it into debugging and calibrating purpose, “PC Data Logger Mode” that sends all calculating result into PC via a serial communication for further processing. The ATMEGA-8 was occupied for several reasons such as easly found, inexpensive price, 28 pins and a huge flash program memory.

The tool could measure within entired HF band, where the frequency is represented by two digits fractional as like as an SWR display. The R and jX are represented by two digits integer number, because a very accurate reading for them is unnecesary. The jX is always positive, due to limitation of the calculation method, however it can be determined by a proper operational procedure.

When the PC.5 is set LOW, it means “Debug Mode” is activated. Normal calculation will be stopped, meanwhile four values would be displayed on LCD, they are Number of Clocks entering T1, Pure integer value read by ADCs – Vin, V50 and Vout. This mode is quite worked for me.

If we need to record calculation result into PC for further processing, such as plotting into spreed sheet or simply create a graphical presentation, we should activated PB.1 to become LOW. This feature will do two things, displaying calculation result into LCD as well as sending it into PC via serial communication simulatnously. Furthermore, when PC.5 and PB.1 are activated together, debug data will be displayed into LCD, at the same time sent it into PC.

Its overall performance has been satisfied my expectation so far. I hope it can solve most Indonesian HAM searching for, an inexpensive, easy construction, locally availabled components and joy of building an own Antenna Analyzer. The Circuit Diagram, PCB Art Work and Firmware HEX for this project are attached in this article, could be freely utilized for personal or education purposes. Please keep my footprint on it.

2. Science Behind

As I had told before, it works using Vector Analysis Method which evaluates three different voltages, they are Vin, V50 and Vout. Vin is input voltage of R50 and antenna/ load. V50 is voltage of the R50, and finally Vout is voltage of the antenna/ load. Kirchoff ‘s Law says that Vin = V50 + Vout. Remember, that equation is not only satisfied real number but also imaginary one. When managing the imaginary number calculation, a Vector Analysis is such an easy way to cope with it. Perhaps, that is way this method was called by. Picture below should give us more easier way to understand what we are dealing with.

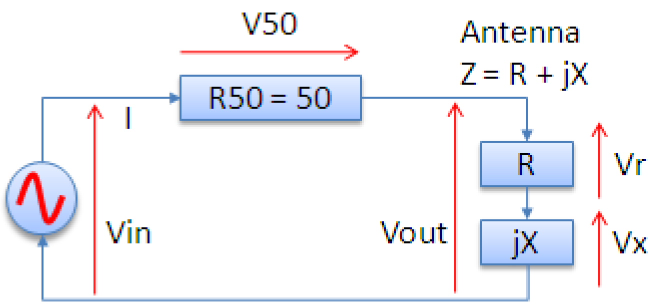


Figure 1 Diode Detector Schematic

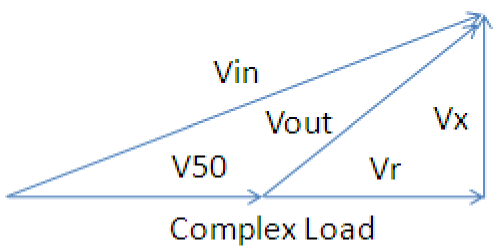


Figure 2 Vector Analysis For Complex Load

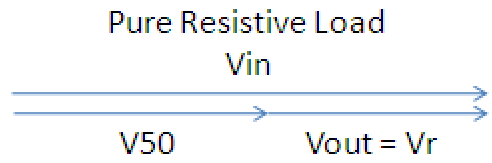


Figure 3 Vector Analysis For Pure Resistive Load

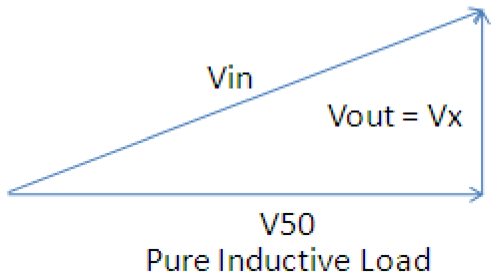


Figure 4 Vector Analysis For Pure Inductive Load

Those pictures clearly shows relation between all three voltages, Vin, V50 and Vout. Two famous postulates are ruled here, they are Kirchoff's Law and Phytagoras's Law. Both laws forces every possible condition occurred in the diode detector is always satisfy an ideal term, so that the calculation will give right results. Here they are:

Let say antenna/ load voltage is Vout = Vr + Vx, where Vr is resistive voltage and Vx is imaginary voltage. We assume that antenna input impedance is Z = R + jX.

Before we go deeply into both Laws, first of all is checking the Vin, V50 and Vout. There are three possible conditions, they are:

- If Vin << (or almost zero), it means VFO is not working. Stop next calculation.
- If V50 << (or almost zero), it means Load is Open Circuit. Stop next calculation.
- If Vout << (or almost zero), it means Load is Closed Circuit. Stop next calculation.

OK, here we come … Kirchoff's Law says …

Vin = V50 + Vout … (i)

Two possible conditions are:

- If Vin ≤ V50 + Vout, condition is verified, assumes the antenna as imaginary load (Z = R + jX) see picture 2.
- If Vin > V50 + Vout, condition is not verified, forces Vin = V50 + Vout, where Vout = Vr, assumes antenna as pure resitor (real load Z = R + j0) see picture 3.

Phytagoras's Law says …

$Vin^2 = V50^2 + Vout^2$ … (ii)

Two possible conditions are:

- If $Vin^2 < V50^2 + Vout^2$, condition is not verified, forces $Vin^2 = V50^2 + Vout^2$, where Vout = Vx, assumes antenna as pure inductive load (Z = 0 + jX) see picture 4.

- If $Vin^2 \geq V50^2 + Vout^2$, condition is verified, assumes antenna as imaginary load ($Z = R + jX$) see picture 2.

Next calculation is solving the values of R, X and SWR as follow:

$Vr = (Vin^2 - V50^2 - Vout^2) / (2 * V50)$ … (iii)

$Vx = SQRT(Vout^2 - Vr^2)$ … (iv)

$I = V50 / 50$ … (v)

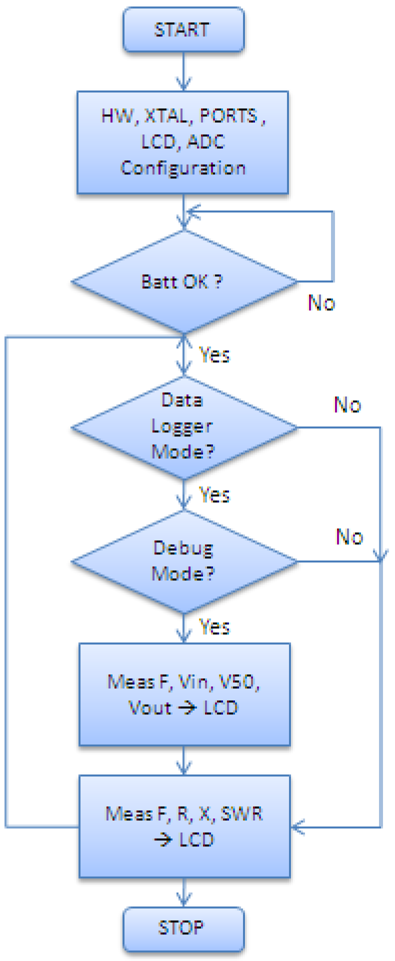
$R = Vr / I$ … (vi)

$X = Vx / I$ … (vii)

$X = SQRT((R + 50)^2 + X^2)$ … (viii)

$Y = SQRT((R - 50)^2 + X^2)$ … (ix)

$SWR = (X + Y) / (X – Y)$ … (x)



Due to limitation of the method, it could only provide positive imajinary value, where is not meant inductive load. Either inductive or capacitive load, the $Vin \leq V50 + Vout$ is always occurred. Now the challenge is how to determine whether the load is inductive or capacitive. Since imajinary load could have two possibilities, i.e. inductive $jX = jwL$ and capacitive $–jX = 1/jwC$, where $w = 2\pi f$. By increasing the f (frequency) slightly during measurement and evaluating the changing of imaginary value shown by LCD, we can determine what the imaginary load is. If imaginary value shown by LCD is increased that it means inductive load and vice versa.

3. What Does MCU Do ?

ATMEGA-8 is occupied using external X'tal clock, i.e. 8MHz (it has top maximum value of 16MHz). Different with other MCU outside there, the ATMEGA-8 will do as fast as its X'tal clock i.e. 8MIPS (Mega Instruction Per Second), such a quite fast computation ability. It has 24 pins, where all of them are fully occupied efficiently. Please note, I use ATMEGA-8, not ATMEGA-8L, however both can be used fit with our firmware. They have some different abilities, such as their top external X'tal frequencies, i.e. 8MHz for ATMEGA-8L and 16MHz for ATMEGA-8. Since each location will have different available component, so that I chosed the 8MHz external X'tal in order to make the design more adaptabled.

A easy found and unexpensive 16x2 LCD is attached at PORTD and PORTB, using 4 bit mode. Meanwhile some of the ADC Port (PORTC) are used for Battery Checking (ADC0), Vin (ADC1),

V50 (ADC2) and Vout (ADC3). The rest are utilized as other purposes, i.e. ADC4 for controlling the frequency counter gate (74LS00) and ADC5 for controlling value added feature "Debug Mode" at LOW state. Other value added feature that is "Data Logger" via serial communication into PC is activated by set "LOW" the PORTB.1, thus data will be transmitted and received via PORTD.1 and PORTD.0 respectively. Both two features mentioned above could be run simultanously. Frequency counter is done by using T1 interupt, where the clock signal enters MCU via PORTD.5. A High-Speed CMOS Logic Dual 4-Stage Binary Counter 74HC393 is occupied to pre-scale incomming clock at 1:64 ratio. Its reset controller is not used in order to keep it simple hence reduce number of MCU's PORT utilized as controller. For two digit fraction frequency display, it doesn't give any error significantly. The last four PORTs, i.e. PORTB.2 till PORTB.5 are roled as ISP – In Circuit Serial Programming, it is such my favourite feature. Generally, the MCU will do procedures as depicted in the flowchart.

4. How The Hardware Works ?

As depicted in the block diagram below, the HPMAA is consisted of 5 main blocks, they are:

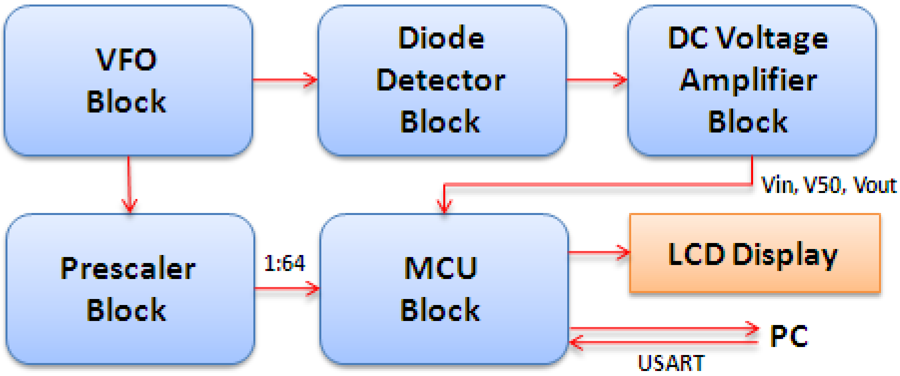


Figure 5 Homebrew Poor Man Antenna Anlyzer's Block Diagram

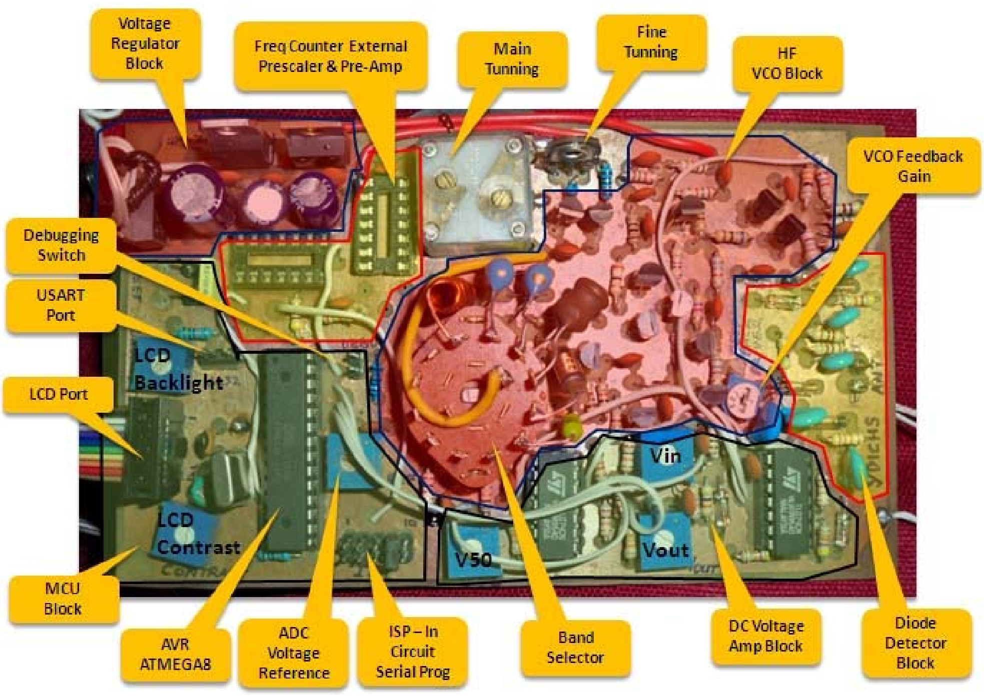


Figure 6 Block Position and Component Layout

VFO Block

The Vector Analysis method requires a constant amplitude for entire measuring frequency range, in this particular case is HF Band 0.5-30MHz. Syntheziser was done by T3, where the oscillation frequency is determined by tank circuit that is formed by Bank of Inductors, Varco as well as T1 and T2 that are acted as varactor diode “Fine Tune”. Band range is changed by manual rotary switch. The configuration is quite simple and conventional in order to keep its simplicity, hence reduce cost and development difficulty.

T7 is ruled as buffer and signal sampler that is used as negative feedback into syntheziser, by controlling internal resistance of the T4 and T5, hence stabilizes the amplitude produced by syntheziser. T6 is ruled as RF small signal amplifier loaded into rectifier D3. D3 changes incoming RF signal (AC) to became a Directing Current (DC). T8 is done as a buffer, which is fed into a broadband RF Pre-Amp formed by T9 and T10. Finally, to boost the signal T11 and T12 are occupied as broadband RF Amplifier. In order to increase the accuracy it is supplied by 12 volt, hence give output that will be swinged max. 12V peak-to-peak. The signal has to be able to activated diode detector beyong the VFO.

Diode Detector Block

The detector is formed using three germanium diode, notice: utilizing silicon or other kind of diodes may reduce measurement accuracy and linearity. D4 samples dan rectifies Vin voltage, D5 for V50 and D6 for Vout.

DC Linear Amplifier Block

Signal DC Vin, V50 and Vout then amplified by cascading DC amplifier which are formed by two inexpensive LM324s. A compensated circuits that are formed by D7, D8 and D9 which are the same types with D4, D5 and D6, in order to minimise unlinearity area introduced by D4, D5 and D6, hence keep measurement accuracy.

Each DC amplifier are added variable resistor to control the voltage level fed into ADC-1, ADC-2 and ADC-3. As datasheet said, each ADC input shouldn’t exceed 4.7V. So that, we have to ensure for entire measurement frequency range, the Vin must not exceed 4.7V at an open circuit load.

External Prescaler Block

An analog HF signal should be convert into clock form before fed into MCU via T1. T13 is ruled as simple broadband HF pre-amp that boosts incoming signal to proper level. The 74HC00 does as a buffer as well as signal form converter. It has also gate which controls opening periode of the gate during frequency measurement.

The 74HC393 is occupied as External 1:64 Prescaler before fed into MCU, since MCU maximum frequency that can be measured usualy as high as X’tal Clock used, i.e. only 8MHz (if T Gate is 1 second). Using external 1:64 prescaler can increased top frequency limit to become 512Mhz theoritically, however in real world the 74HC393 top frequency limit is only tens MHz.

MCU Block

As had been told before, the MCU does calculation to determine Frequency, SWR, R, jX and others value added features. I will not decribe it again here.

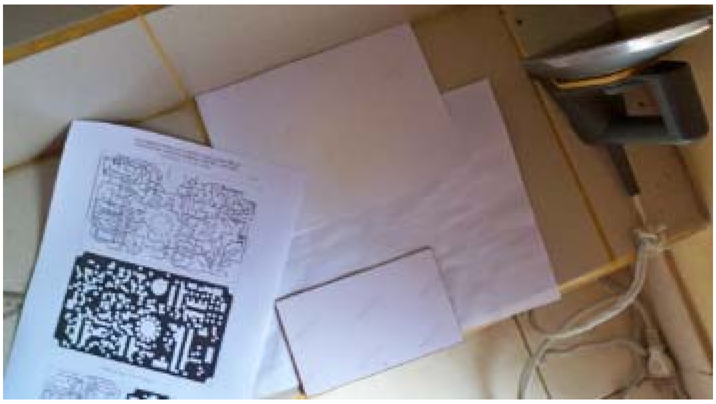


Figure 7 Preparing PCB Artwork on Glossy Photo Paper and Hot Iron

Figure 8 Soaking Into Soap Water

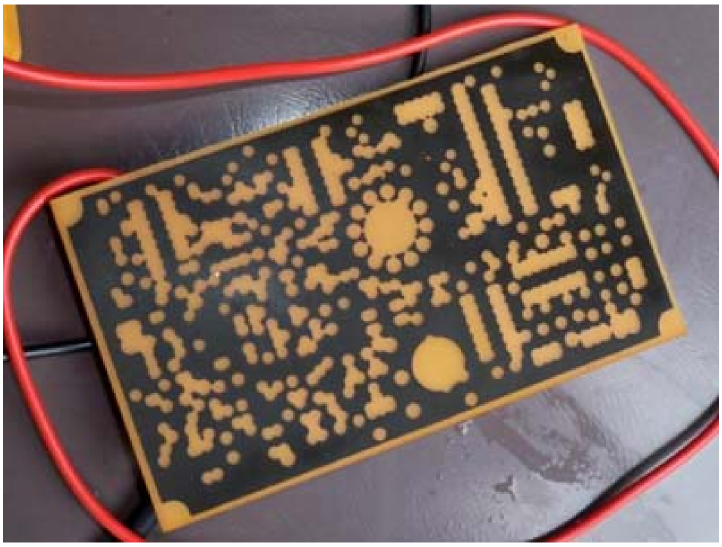


Figure 9 Transferred Artwork At a Double Layer PCB

Figure 10 After Etching – Double Layer: Ground Cladding

5. Development Hints

Working on an HF frequency is full of challenge, but please don't be panic. By proper development tips we can produce a high enough quality design. One should be kept in mind is connecting them as short as possible.

Let me share my priceless experience during developing its prototype on the project board. I used two pieces of project board that were joint together. The MCU and Prescaler blocks were laid on the first board, meanwhile the second one on another board. The result is quite weird and odd, the LCD was not initialized properly, LCD showed random and unreadabled characters. This problem had been made me "head ache" for all day long, while searching tons of information how to solve it on the net, untill incidently I reset it using a piece of wire that connected directly on the LCD's ground supply rail, even the physical jointing is quite good. Finally, I was enlighten that the connection should be done as short as possible with a good common ground supply rail. It remained me to a message on the net, that said an *"EMC issue"* could become a hidden problem that is very difficult to be coped with, that wasn't attract my intention at that time when I found it in the net.

The using of double layer PCB where one side is ruled as flat ground clading is highly recommended. I had prepared art work PCB either single or double layer for your experiment. A proper choosing of the components is also one of our succeed key. Especially for the tank circuit, it is recommended to use a negative temperature components, such as NPO or Polysteren Capacitors. The VFO is free running and has no locking mechanism such as PLL or Huff-Puff, so that its could be not so stable. In the firmware v.1.0, I haven't added a Huff-Puff feature into project. I hope it will be added someday. So please keep tuned for the next update version.

As I had mentioned previously, that the diode detector block and DC amplifier block should utilize germanium diodes with VHF operating frequency ability. The germaniun diode generally has a low forward voltage i.e. about 0.2V. The forward voltage is a voltage threshold that is naturally introduced by a barrier between PN junction. The threshold must be exceeded in order to force diode to be connecting state (active). Unfortunatelly, diode's line that is laid on its active region is not a linear one, that introduces a nature problem, i.e. unlinearity detection, hence influent the overall measurement results. This natural behaviour can be minimise by a compensation circuit, which is formed by same type of diodes used on the detector block. Choosing other diode types should gain worse performance than germanium ones. Unfortunatelly, it is most a challanging one to find germaiun diode at my local market now days. If we unlucky to find them, we can replace

them with germaniun transistor. Still unlucky, so please accept your destiny to replace them with cheap and easily founded silicon diode such as 1N4148 and feel its consequencies. Hi…

Actually, there are other methods can be utilized to calculate antenna's characteristics that were claimed gives better performance than this traditional diode detector, however this old method is the simplest and chepest one, that is fit with my objectives above. Meanwhile, for more perfectionist HAM, I have been developing next week end project using other method which more modern and more expensive.

6. How To Calibrate ?

Since we occupy set of DC amplifier just after the diode detector, so that it is possible the signal level out from the DC amplifier will vary from their actual values, hence will affect into overall calculation results.

Adjusting ADC Inputs

As we had known before, that maximum level permitted into ADC is 5V, above this value the Microcontroller will be simply burned out. So that, please protect your valuable component. Before everything worked properly, I recommend to unconnect three DC amplifier outputs from each ADC input port, i.e. ADC-1, ADC-2 as well as ADC-3.

Between Vin, V50 and Vout, the Vin is always had the highest level. Thus, if Vin level is always <4.7Volt for entire HF Band (at Open Circuit Load), the others voltage will be safe for each ADC input.

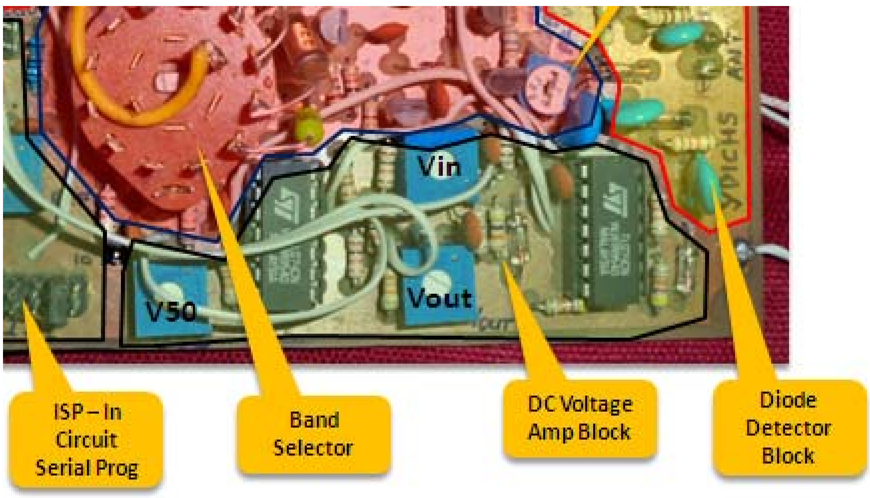


Figure 11 DC Voltage Amplifier

This adjustment can be done by evaluating voltage using digital multimeter at the output of DC Amplifier which boosts the Vin (TP2). Here is the procedure:

1. With an "open circuit load" attached into measuring ports, scan entired HF band by rotating main dial tuner, meanwhile keep eye into digital multimeter reading.
2. Find the frequency where the level is reached its maximum, note this frequency.
3. Tune back the frequency at its maximum (as you had been noted above).
4. Adjust the VR named as VIN until the voltage of the Vin (TP2) is not exceeded 5 Volt, let say 4.5 Volt. Something should remember, the higher is more accurate, however we have to

protect the microcontroller anyway. In PCB actually I had added a place for a 4.7V Zener Diode, but I haven't test it yet.
5. For a while, Vin adjustment is finish.

Now we have to adjust both V50 (TP3) and Vout (TP4). The procedure is follow:

1. Firstly, attached a accurate Resistor, let say 50 Ohm with 1% tolerance, into measurement ports.
2. Set the frequency at the centre of HF band, i.e. 15MHz.
3. Measure the Vin (TP2), by adjusting both VR named V50 and VOUT, both V50 (TP3) and Vout (TP4) should have voltage level half than Vin (TP2). Let say, if Vin = 4.5 volts, both V50 and Vout should be 2.25 volts.
4. Do the same procedure for some different frequencies.
5. Do the same procedure for several value os resistors, for example: 100 Ohm 1%, 2 serial 10 Ohm 1% or 20 Ohm, etc.

Adjusting Frequency Meter

Since frequency meter uses an internal software to measure the VFO frequency, we can not adjust it unless recompling its firmware. However, a sligthly adjustment still can be done by triming a VC attached on the X'tal 8MHz. It is ruled as VXO. But please, don't force it to go to far from its fundamental frequency. I designed this frequency counter with a low accuracy, because it is only display maximum 5 digits, including 3 fraction digits.

7. Its Performance

Figure 12 Frequency Measurement Test

Figure 13 SWR, R and X Measurement Test

This paper was written at 23th October 2010 where the project has not been completed yet. Several problem were still existed, they are:

- The signal waveform at the last band (21-32MHz) have both unpure sinusoidal and quite small amplitudo, hence introduces unaccurated and unreliabled measurement result. The non sinusoidal waveform at the time domain means uncleaned spectrum at the frequency domain. Meanwhile, small amplitudo forces the diode detector to be worked at its unlinear zone (near to its cut-off zone). I will manage to this problem at the near future, so please stay tune.
- Even the frequency counter algorithm had been working properly, but I haven’t install its external pre-scaler circuit at my project. My consentration is still at the VFO.

I have tried to measure several resistor’s values for this occasion, they are 26 Ohm (two parallel 51 Ohms), 50 Ohm (two parallel 100 Ohms) and 110 Ohms (two parallel 220 Ohms) by ignoring the last band i.e. 21-32MHz. The result was satisfied my expectation, the tool had been succeed to measure near to its real value, meanwhile the VFO stability was acceptable for most bands.

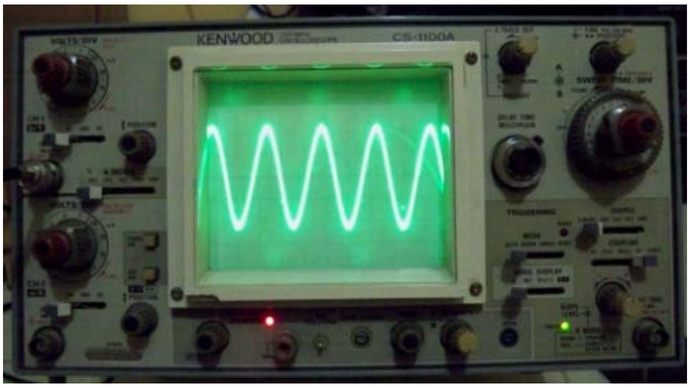


Figure 14 VFO output waveform 1.6-20MHz – Perfectly Sinusoidal Waveform

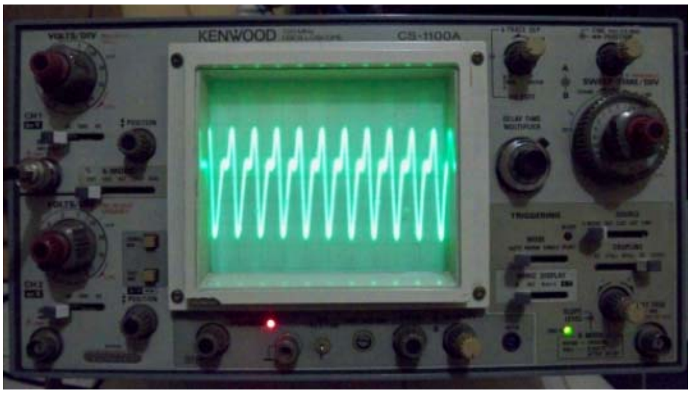


Figure 15 VFO output waveform 20-32MHz – Uncleaned Sinusoidal Waveform

8. Opportunity For Improvement

The tool has not been enclosured yet, since the experiments is still in progress. A simple grounded metal or PCB box might improve its performance.

I thing we can add a simple Frequency Locked Loop (FLL) for its VFO, however it could introduce an additional delay for the whole process, but worthy to be tried in order to improve the VFO’s stability.

An additional small signal RF amplifier might be inserted on the VFO, since its highest band amplitude signal is quite small, in order to improve measurement reliability.

9. References

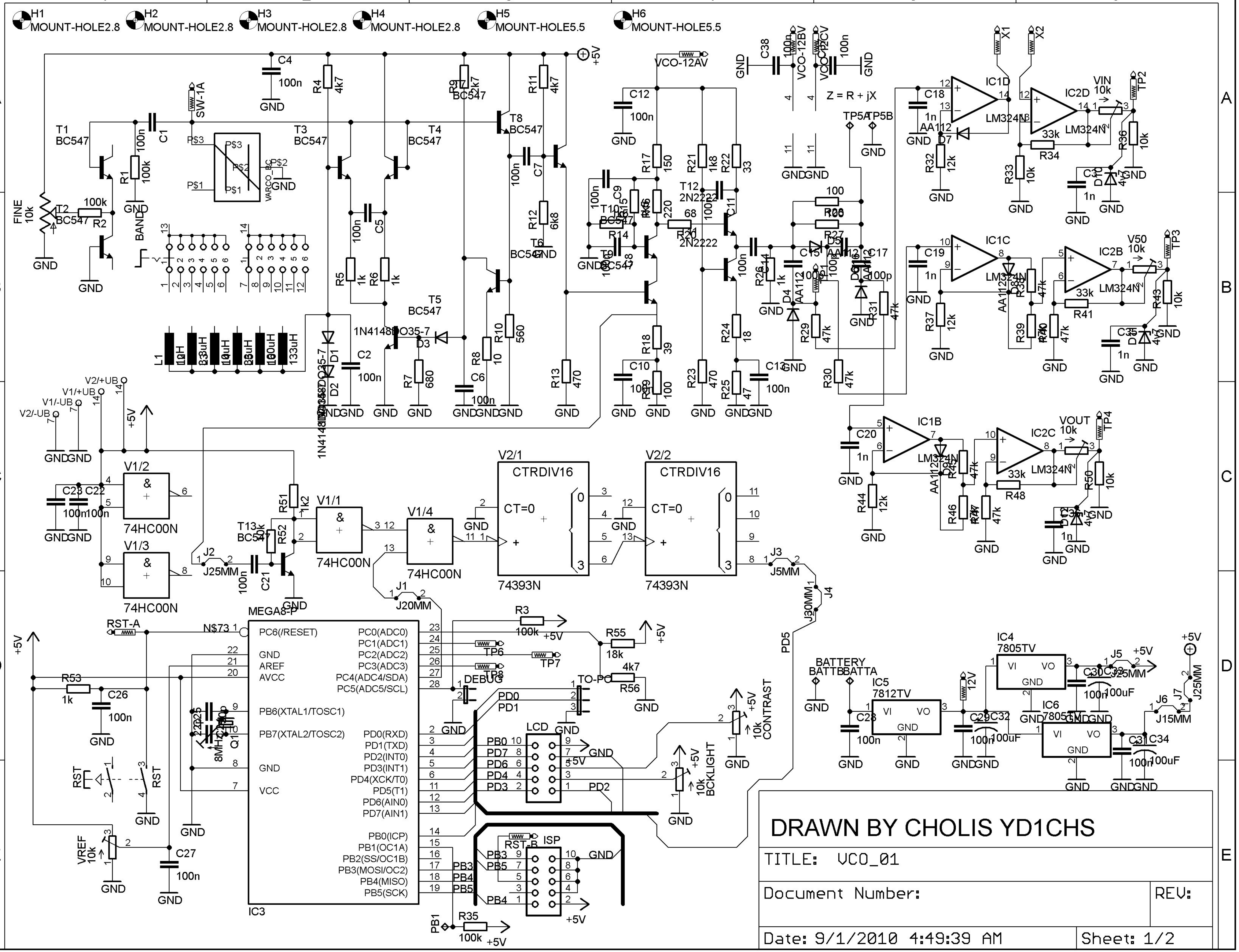
[1]. www.users.on.net/~endsodds/analsr.htm - The VK5JST homepage. It contains tons of informations regarding to the VK5JST Aerial Analyzer. It is a must read site.

[2]. http://www.zl2pd.com/digitalZmeter.html - The ZL2PD homepage. It contains a modification type of the VK5JST Aerial Analyzer, mainly on its VFO and Microcontroller board.

[3]. http://www.xs4all.nl/~pa0fri/Diversen/VK5JST/Ant analyzereng.htm – The PA0FRI homepage. It containts modification of the VK5JST at most blocks.

[4]. http://www.rigexpert.com/index?s=articles&f=aas – Short Review about method behind famous antenna analyzer in the world. It is quite recommended page to be written.

[5]. http://www.atmel.com/ - The ATMEL official homepage.



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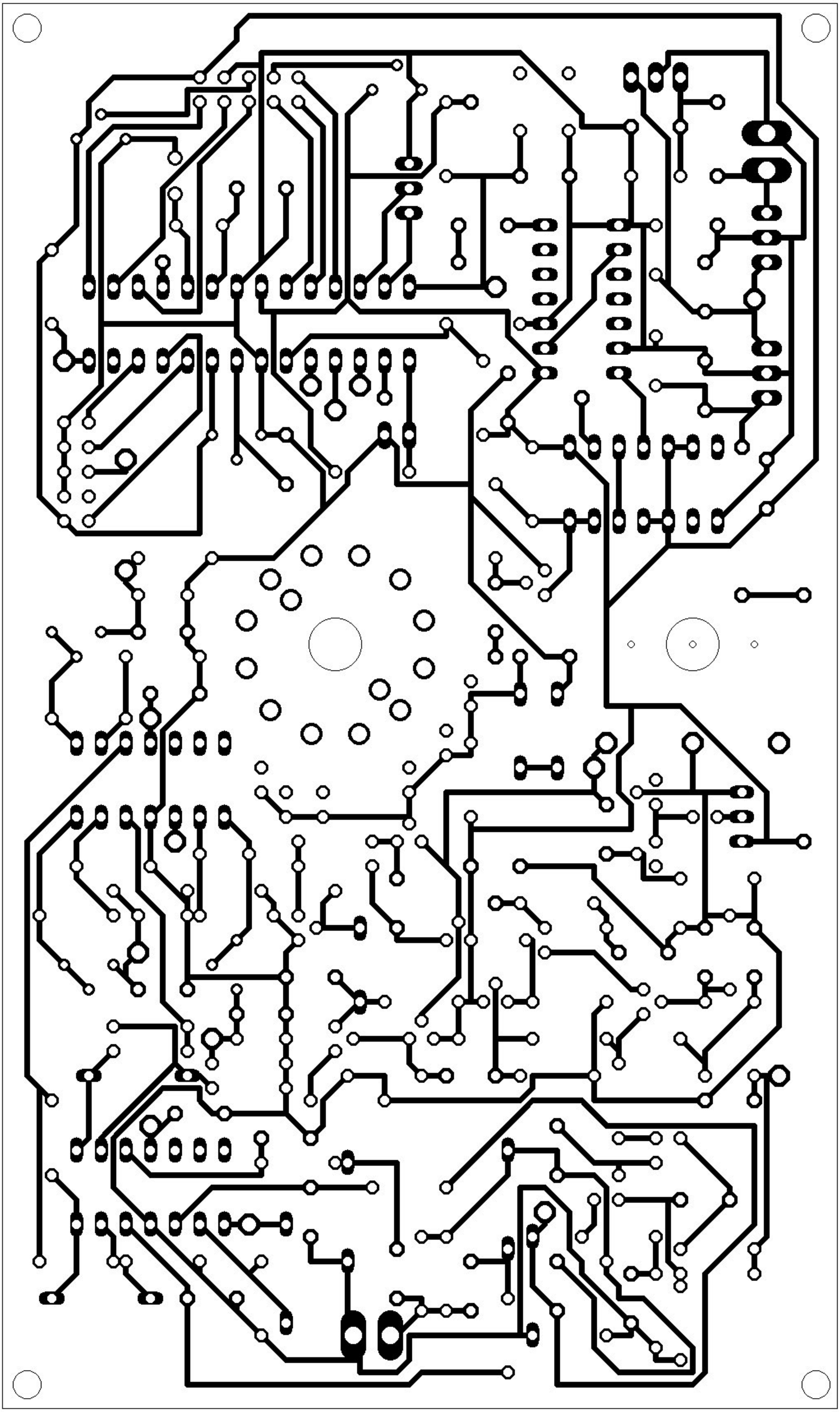
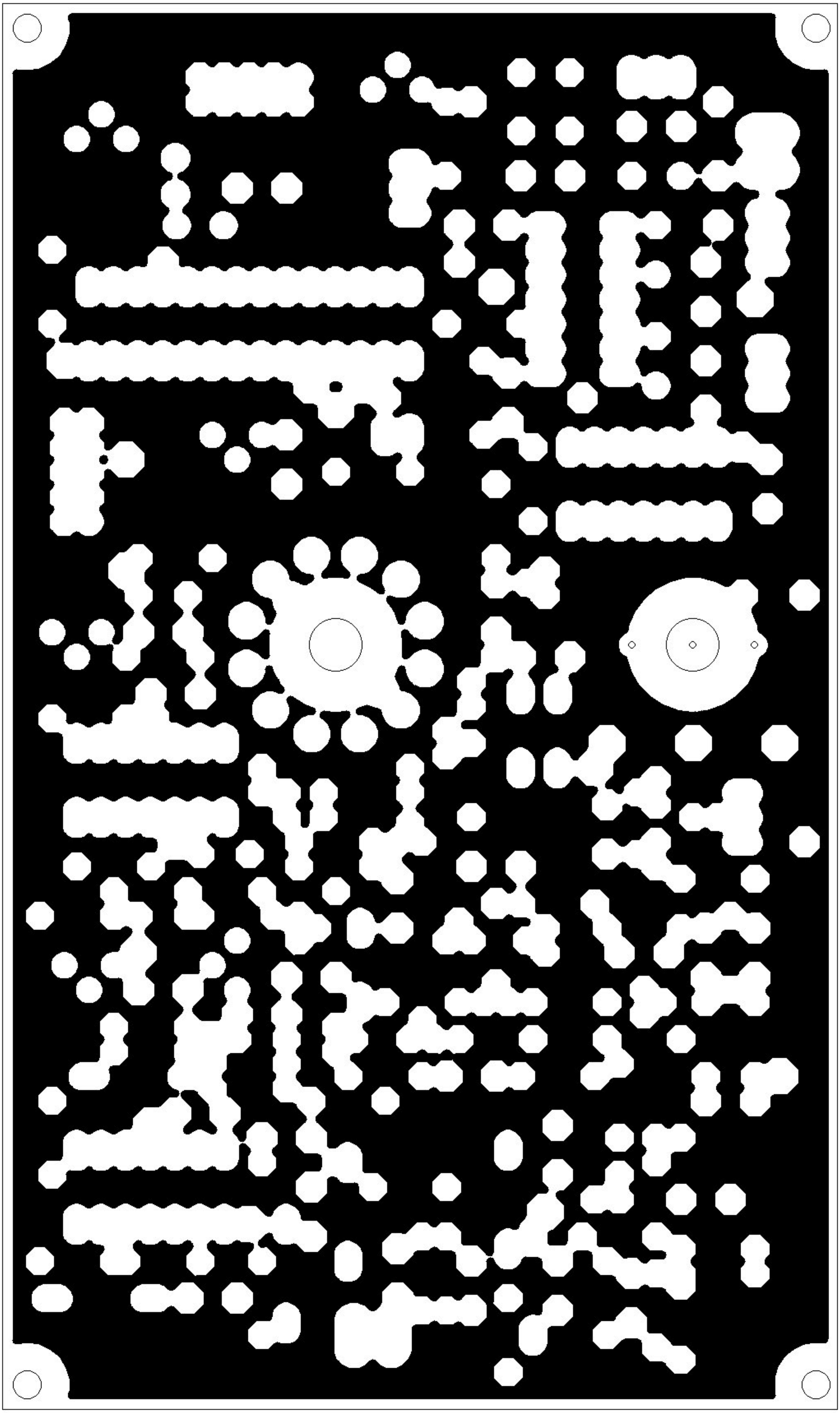




50 MHz converter

RE-RXC50/10

Receive singals from the "Magic Band" on your shortwave receiver!

About the 6-meterband converter RXC50/10:

This is a very sensitive 50Mc converter allowing you to receive the entire "Magic Band" (50Mc...52Mc) on your general coverage receiver (28Mc...30Mc). It receives all types of modulated transmissions. It all depends on the receiver used. I've tested this project on a allmode Yaesu FRG-100 receiver. Within certain limits you can change the output frequency to suit your needs. The converter is very stable, low nois, sensitive and low on power consumption and can be compared to many commercial 50Mc receivers.
The heart of the converter has been built around Philips SA602 (NE602 or NE612), a twice balanced mixer oscillator. This IC finds his applications in layer capacity communication systems, cellular radio applications, RF data left, VHF-transceivers, broadband LAN's ed. IC in a ordinary 8-pin dual-in-line can be bought implementation (DIP) or 8-pin SO (surface-mount miniature package) implementation. Both implementation has a low cost. SA/NE602 a very low usage of only 2,4mA has! The total usage of the converter amounts to only 15mA. Therefore also uncomplicated usable applications fed with battery.

The SA602A is a low-power VHF monolithic double-balanced mixer with input amplifier, on-board oscillator, and voltage regulator. It is intended for high performance, low power communication systems. The guaranteed parameters of the SA602A make this device particularly well suited for cellular radio applications. The mixer is a “Gilbert cell” multiplier configuration which typically provides 18dB of gain at 45MHz. The oscillator will operate to 200MHz. It can be configured as a crystal oscillator, a tuned tank oscillator, or a buffer
for an external LO. For higher frequencies the LO input may be externally driven. The noise figure at 45MHz is typically less than 5dB. The gain, intercept performance, low-power and noise characteristics make the SA602A a superior choice for high-performance battery operated equipment. It is available in an 8-lead dual in-line plastic package and an 8-lead SO (surface-mount miniature package).

50 MHz converter technical specifications

- Frequency range from 50.000 MHz to 52.000 MHz
- 50 Mc in = out 28 Mc (or 26Mc when using 24MHz LO Xtal)
- Power supply = 9...18v max
- Total power consumption = 15mA (LED included)
- Power consumption IC1 = 2,5 mA

- Sensitivity = 0.22uV at 12dB SINAD
- Mixer noise figure = 4,6dB
- Input impedance = 50 Ohm
- Output impedance = 50...600 Ohm
- Local oscillator 22MHz
- Frequency stability = +/- 5Hz
- Operating ambient temperature range = -40 to +85°C

RXC50/10 SCHEMATIC

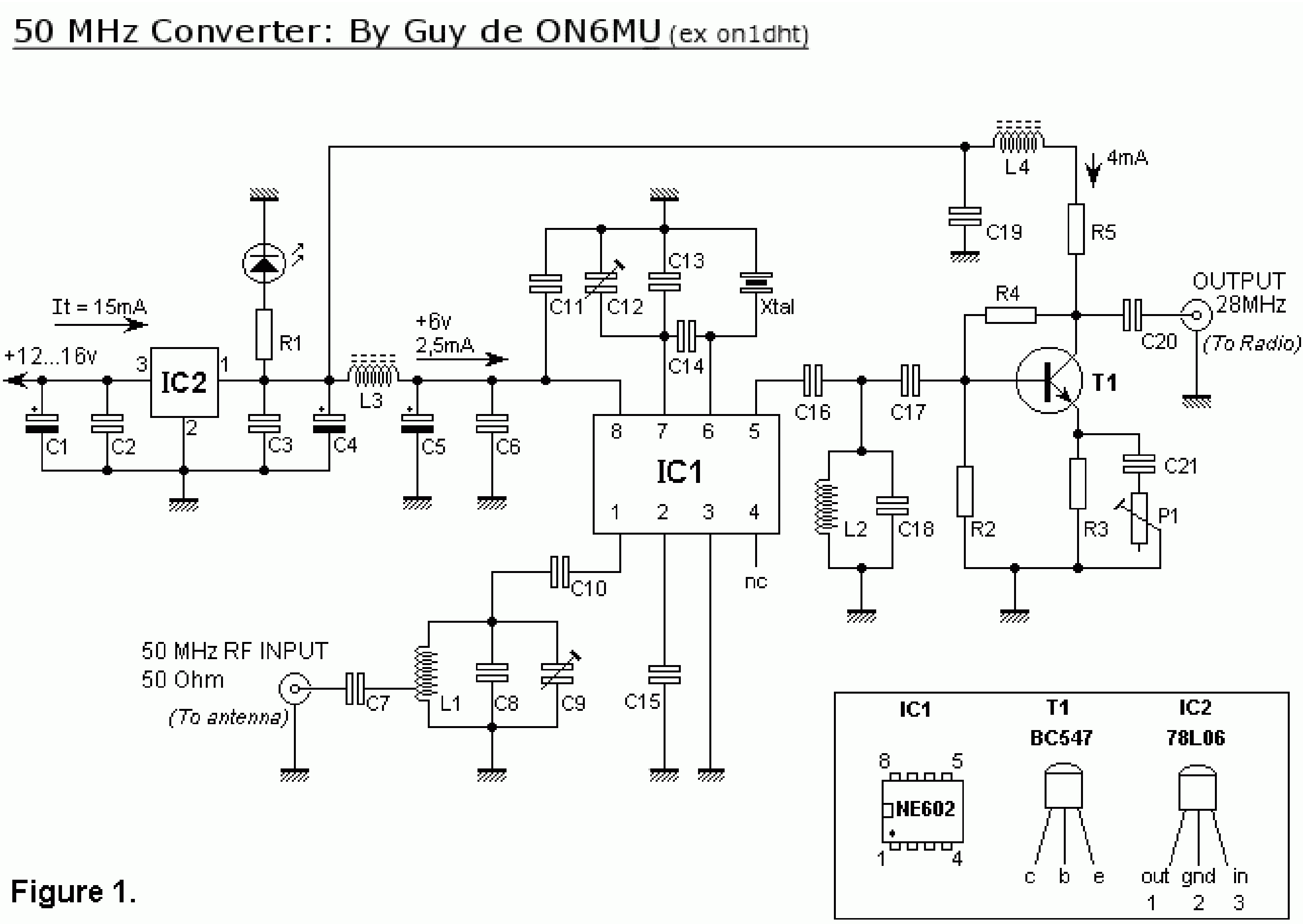


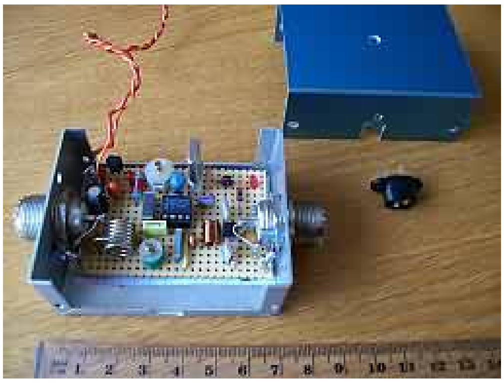
Figure 1.

PARTS

IC1 = NE602, NE612, SA602A, SA612A
IC2 = 78L06
T1 = BC547 or BC338
C1 = 10uF/25v
C2 = 100nF
C3 = 100nF
C4 = 10uF/25v
C5 = 47uF/16v (tantaal)
C6 = 47nF (polyester)
C7 = 47pF
C8 = 22pF
C9 = 0...22pF (green)
C10 = 2n2
C11= 4.7nF
C12 = 0...40pF (white)
C13 = 47pF (poly)

C14 = 39pF (poly)
C15 = 47nF (polyester)
C16 = 330pF
C17 = 330pF
C18 = 100pF*
C19 = 4.7nF
C20 = 470pF
C21 = 470pF
P1 = 100 Ohm
R1 = 1k
R2 = 2k2
R3 = 100 Ohm
R4 = 5k6
R5 = 1k
P1 = 100 Ohm

Coil specifications:
L1 = 7 wnd 1mm silver 9mm coildiameter (drill 7), tap on 1,5 wnd from the cold end.
L2 = 11 wnd 0,6mm email 5mm coildiameter (drill 4)
L3, L4 = shokes (RFC) 10uH +/- or use a ferite bead

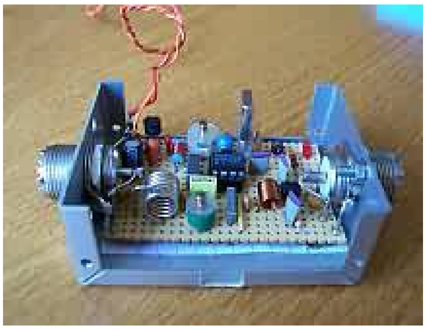


The converter explained

The heart of the converter has been built around Philips SA602 (NE602), a double balanced mixer oscillator. This IC finds his applications in layer capacity communication systems, cellular radio applications, RF data left, VHF-transceivers, broadband LAN's ed. IC in a ordinary 8-pin dual-in-line can be bought implementation (DIP) or 8-pin SO (surface-mount miniature package) implementation. Both implementation has a low cost. SA/NE602 a very low usage of only 2,4mA has! The total usage of the converter amounts to only 15mA. Therefore also uncomplicated usable applications fed with battery.
The mixer is Gilbert cell tip quadrant configuration which 18dB can provide conversion gain. The built in Local oscillator work to maximum 200MHz tank oscillator coordinated with a high Q or crystal oscillator. The highest frequency which we can bring to the input of this IC amounts to 500MHz.
In this project we apply a crystal retrieve oscillator. Frequency stability is excellent and depends mostly of the surroundings temperature crystal then the IC itself. As it happens, a very ingenious and efficiently temperature compensating bias is built in. Important to know is that the oscillator already has an internal bias and therefore don't need extra dc-bias. Only at very high frequencies a raised direct current can be necessary. This one remedies by placing between the mass and resistor at pin 7 of a value of of 22k.
The NE602 LO works up to 200MHz and the input up to 500MHz, therefore a huge 'reserve' is available since we use a much lower LO input frequency. We want to convert, as it happens, 50MHz to 28MHz. This means therefore that we must mix with a frequency of 22MHz, meaning 50MHz - 22MHz = 28MHz output. To allow the converter to be calibrated to obtain the exact frequency, a regulable condenser of 40pF (C7) is added to the oscillator. With this you can vary the termination frequency of the converter +-300 Hz.

Without much adapting you can also use the more currently available 24MHz crystal, but then the termination frequency of the converter will be 26MHz ipv 28Mhz (24MHz LO + 26MHz OUT = 50MHz IN).
The Gilbert cell is a differential amplifier which has balanced cell feeds. The differential gives extra gain and stipulate the noise number as well as the strong indicator behaviour of the recipient/converter. And these processes values up to -199dBm with 12dB S/N ratio. The symmetrical RF input (pin 1 and 2) has internal bias, thus we avoid external DC bias (to see C10 and C15)! THE RF input amount to capacitantie 3pF. There we connect single-ended coordinated LC-kring with parallel a resonance a frequency of 50MHz. These can peaked to best reception with C9. This is done best on a frequency where we want best sensitivity, for example 50,220 MHz. To start, move C9 in the middle position. When we have wound the coil L1 correctly, C9 does not need much to be adjusted. If there is no station to tune in to, then regulate C9 till you hear maximum noise.
To have a 50 ohm input by means of C7 and a tap at 1.5 turns from the cold end of the coil. Of course you'll need on 50MHz tuned antenna too HI.
The sensitivity of the converter amounts to 0.22uV at 12dB SINAD. Third-order the intercept point is -13dBm. This is approximately +5dBm output interception because of the RF gain.
The mixer has an internal DC-bias, by means of we connected the output (pin 4 and 5) with a 1k5 resitor to Vcc. Disengaging of the bias happens by means of C16, since we exploit here only a single termination instead of a balanced output. A balanced output will improve something, but to keep the schematic diagram simple, I have not applied this.
To allow only the 28Mc signal to pass through to T1 and into your radio I added a bandpass filter made out of C16,C17,L2 and C18. How crazy it may sound it actually improved the gain too.
The termination capacitance of the mixer (pin 5) amounts to 1.5kOhm. Given the termination indicator and the RF output voltage is a bit on the low side to connect directly to the recipient (radio), there is a amplified step to added which exists from a single BC547 transistor and als serves s a buffer between your receiver and NE602. With P1 one regulates the termination level (amplification) of the converter according to the entrance sensitivity of your communication receiver. The ideal setting is when we have the best singla/noise ratio. For the most the centre setting of P1 should be sufficient. An signal/noise ratio improvement can be made by using dual-gate mosfet ipv BC547(or BC338). The noise number of SA/NE602 is 4,6dB at 20°C and T1 ads its own noise level to it, as a result we end up with an average noise number of approximately 5dB.

C18 and L2 acts like a bandpass in this schematic. It passes signals approx. 26...30MHz. If using another LO frequency it could be needed to tweak C18. So it isn't a bad idea to uses a variable capacitor (trimmer) to fine tune the bandpass in this case.



More about the SA602 (NE602, SA612) in this project

The SA602A is a Gilbert cell, an oscillator/buffer, and a temperature compensated bias network as shown in the equivalent circuit. The Gilbert cell is a differential amplifier (Pins 1 and 2) which drives a balanced switching cell. The differential input stage provides gain and determines the noise figure and signal handling performance of the system.
The SA602A is designed for optimum low power performance. When used with the SA604 as a 45MHz cellular radio second IF and demodulator, the SA602A is capable of receiving -119dBm signals with a 12dB S/N ratio. Third-order intercept is typically -13dBm (that is approximately +5dBm output intercept because of the RF

gain).
Besides excellent low power performance well into VHF, the SA602A is designed to be flexible. The input, RF mixer output and oscillator ports can support a variety of configurations provided the designer understands certain constraints, which will be explained here.
The RF inputs (Pins 1 and 2) are biased internally. They are symmetrical. The equivalent AC input impedance is approximately 1.5k || 3pF through 50MHz. Pins 1 and 2 can be used interchangeably, but they should not be DC biased externally.
The oscillator is capable of sustaining oscillation beyond 200MHz in crystal or tuned tank configurations. The upper limit of operation is determined by tank “Q” and required drive levels. The higher the “Q” of the tank or the smaller the required drive, the higher the permissible oscillation frequency. If the required LO is beyond oscillation limits, or the system calls for an external LO, the external signal can be injected at Pin 6 through a DC blocking capacitor.
External LO should be at least 200mVP-P. It is important to buffer the output of this circuit to assure that switching spikes from the first counter or prescaler do not end up in the oscillator spectrum. The dual-gate MOSFET provides optimum isolation with low current. The FET offers good isolation, simplicity, and low current, while the bipolar transistors provide the simple solution for non-critical applications. The resistive divider in the emitter-follower circuit should be chosen to provide the minimum input signal which will assure correct system operation.

Notes:
Tune to the desired bandpass frequency (50Mc) with C9 until you have the best reception.
Use C12 to calibrate the output frequency to your receiver. The output frequency can be adjusted up to 300Hz.
The output HF-level can be adjusted with P1. Regulate it according to the sensitivity of your receiver.

Other output frequencies can be set by changing the 22MHz Xtal: Example: output frequency is 26 MHz then you use a 24 MHz Xtal (50MHz - 24MHz = 26MHz).
Build the converter in a metal box and use small connections between the parts.

Important: use only a antenna designed for 50MHz! A simple dipole of around 3 meters in length (two times 1,45 meters) will work just fine if the propagation is there. Look at my homebrew site for a 3-element beam that works much better then a dipole and gives more gain, or a my 1/2 lambda vertical antenna.

More info about the 50MHz band (6 meters, the Magic band...) can be found at my site at MagicBand or Radioamateur Info.

PCB:
A PCB has been designed for this project by ON1MFW. E-mail me for detailed high resolution image of the PCB. Example: PCB-parts side PCB layout

Detailed information and manual (in Flemish (Nederlands)) ON6MU's 50MC CONCVERTER MANUAL

Technical graphs:

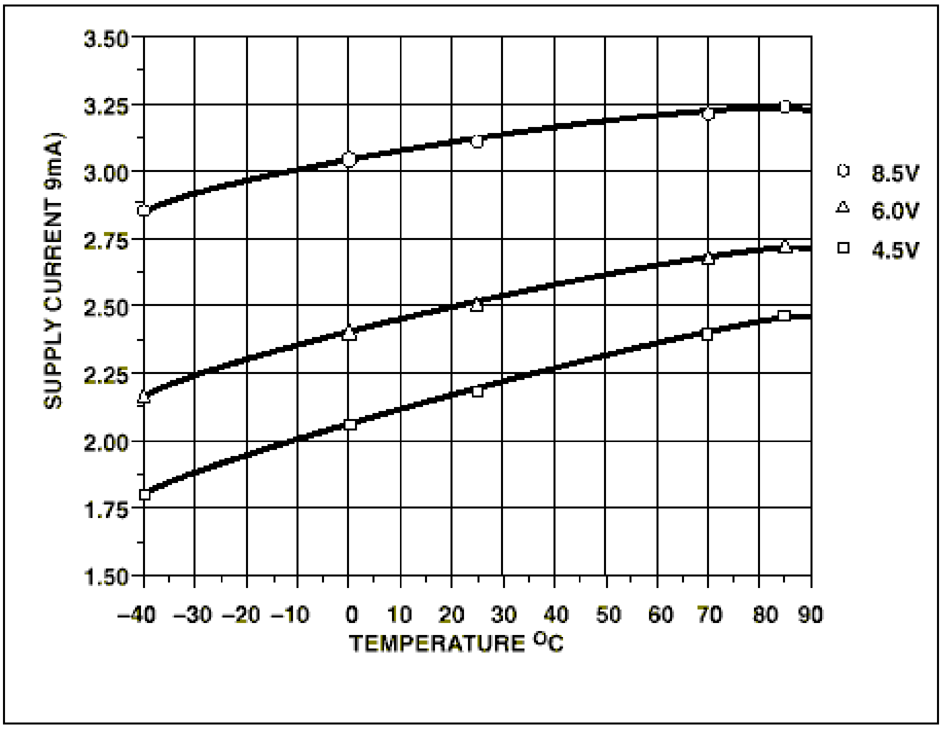


Figure 2. I_{CC} vs Supply Voltage

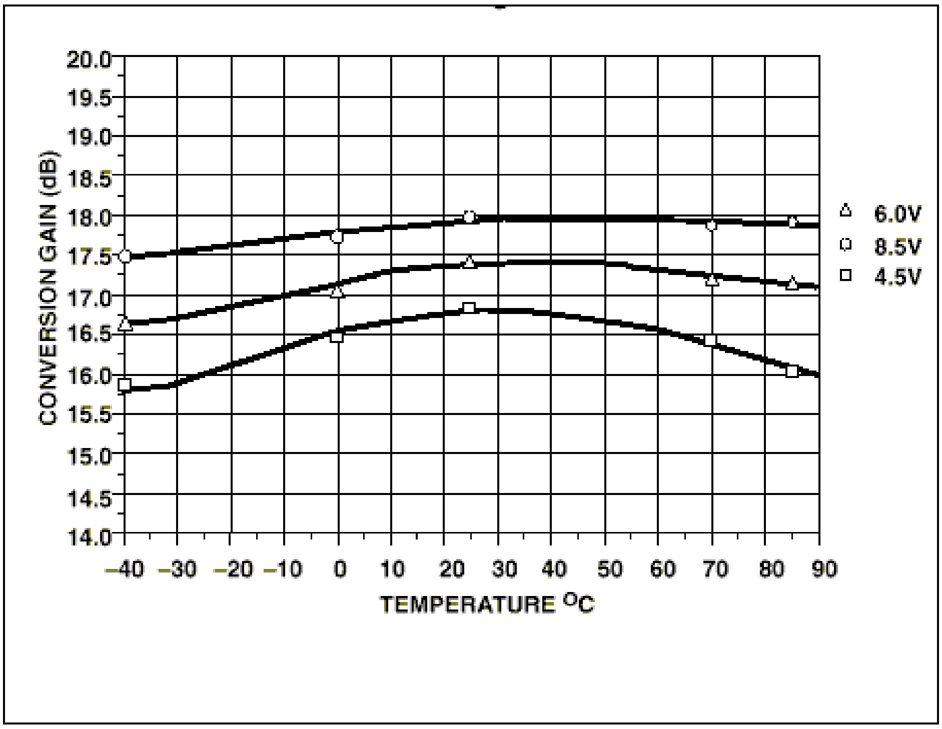


Figure 3. Conversion Gain vs Supply Voltage

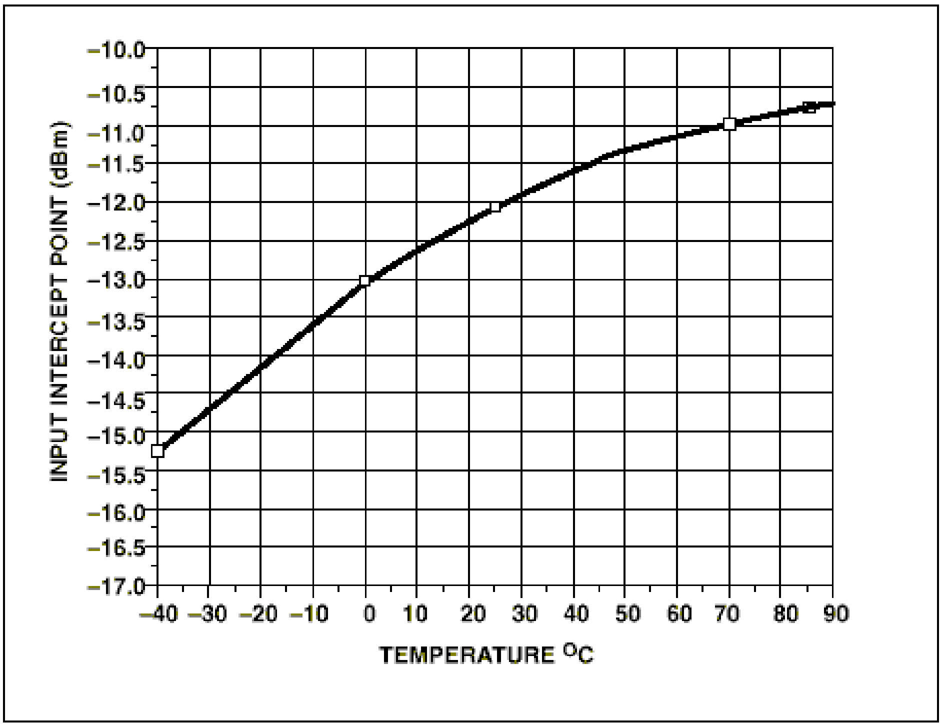


Figure 4 . Third-Order Intercept Point

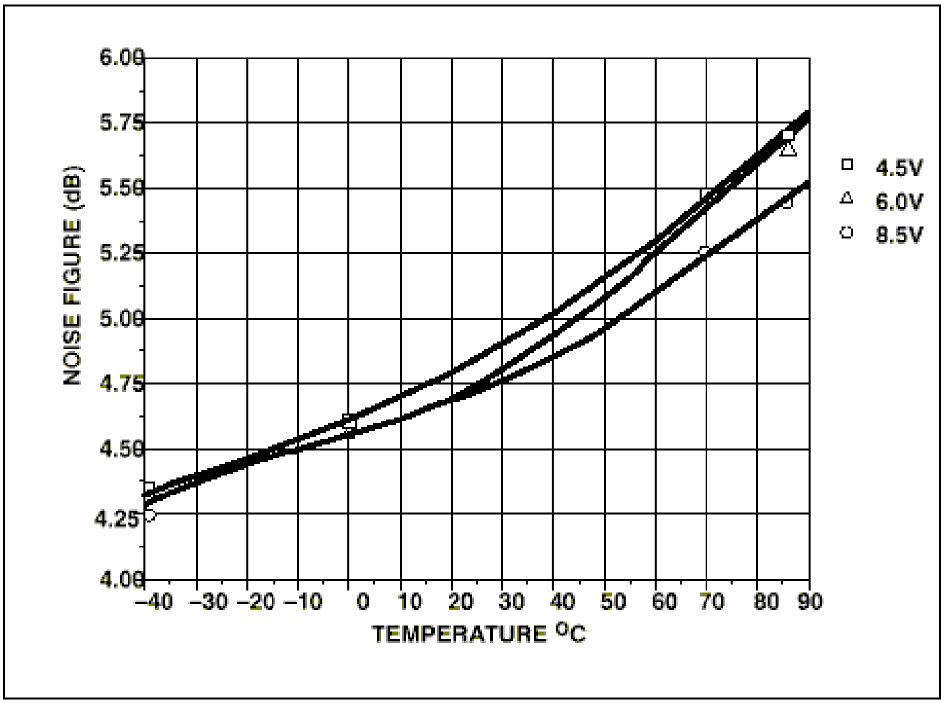


Figure 5. Noise Figure

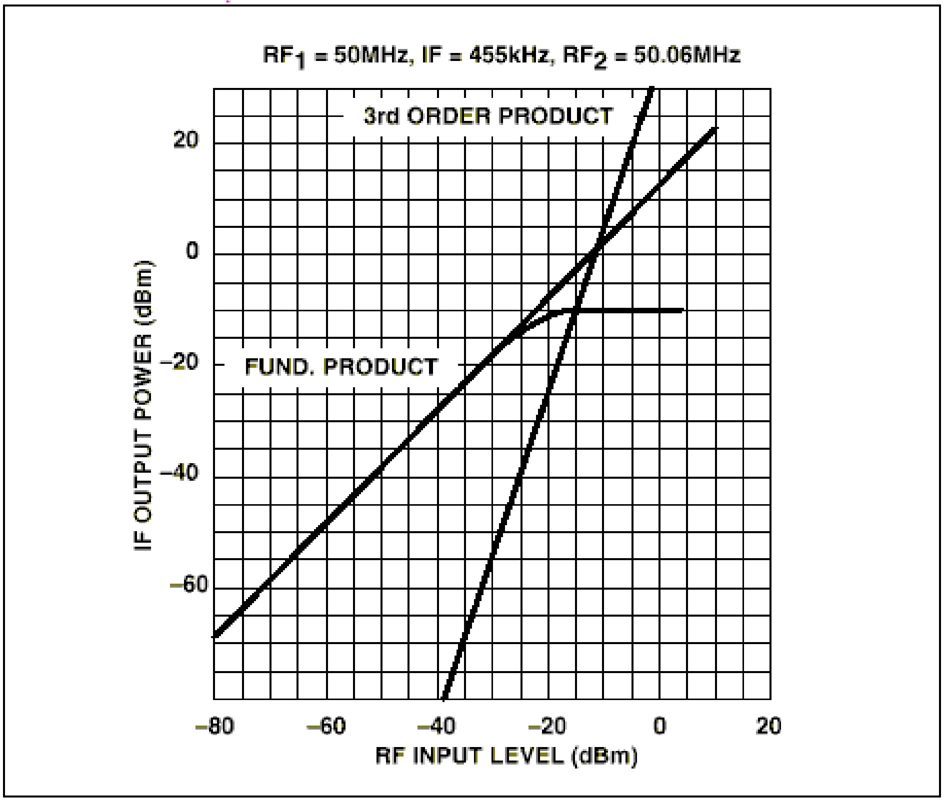
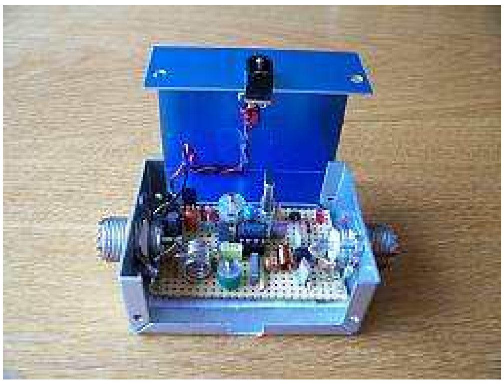


Figure 6. Third-Order Intercept and Compression

This project has been published in CQ-QSO (in Dutch and French) the ham-radio magazine of the UBA.
Magazine 06-07/2000 pages 14,15,16 and 17.

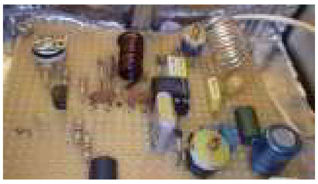
Afdrukken van dit project

More about his:



How Geoffrey F4FVI made it:



Thanks Geoffrey for the pictures!

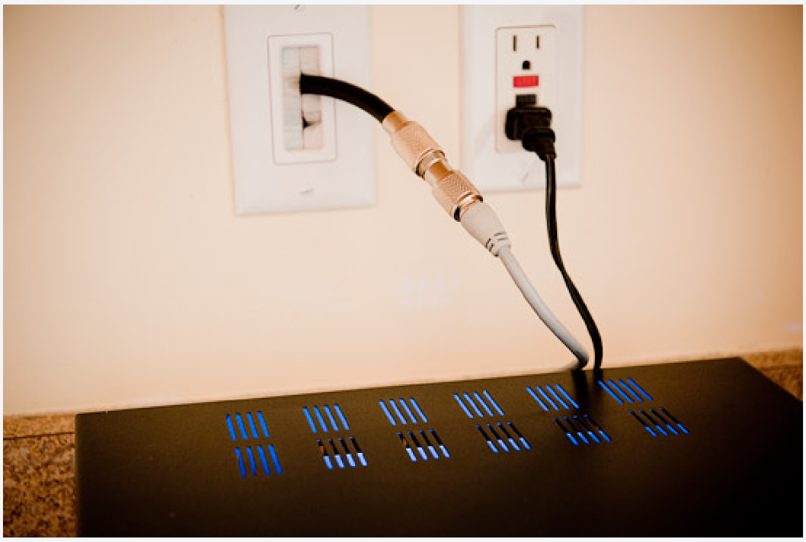
My E-mail

Note: if you want to commercialise, publish or distribute this project then you need to ask permission to do so.

[home]

[mail] [shack] [homebrew] [software] [satellite]
[haminfo] [mods]

Back to ON6MU **Homepage**


Ran the coax across the basement ceiling, and up into the kitchen. I like that brush wall-plate.

The coax terminates at my Uniden Washington base station. Nice radio.

Antenna Tuning - High SWR

After getting everything installed, I realized the antenna was giving me high SWR readings. The SWR was in the high 2's on Channel 01 and 20, and 3+ on Channel 40. It was time to start tuning the antenna. In my case, the SWR on channel 40 was greater than on channel 1, so the antenna was considered "LONG" and a reduction of conductor length is what was needed to correct it. There's a tiny wire that wraps around the Firestik® fiberglass antenna forming a coil and goes all the way up to the tip. You can actually see it through the plastic sleeve of the antenna when looking at it closely. This wire is what needed to be shortened, not the fiberglass itself. Here's a link to FireStik's website with information about tuning an antenna: http://www.firestik.com/Tech_Docs/Setting_SWR.htm

(***NOTE:*** The following was done to both the top and bottom antenna. You want each antenna to be the same length. So, for example, when you read that I snipped 2 coils that means I snipped 2 coils from each antenna. Whatever I did to one antenna, I did to the other before checking SWR.)

Basically, you unwrap the coil and then snip. The first time I was a bit nervous, so I unwrapped and snipped off only two coils of wire. This didn't change the SWR much. The next time I unwrapped/snipped off 4 coils. I saw a change in the SWR and it was getting closer to where it needed to be, but it was still not good enough. The next time I snipped off 5 coils (I probably shouldn't have gotten this bold, but it ended up ok). After removing 11 coils of antenna wire so far, here were my SWR readings:

Channel 01: 1:1
Channel 20: 1.4:1
Channel 40: 1.6:1

It's not too bad, but I wanted to snip some more. I decided to be SUPER conservative though. I didn't want to cut too much wire and then end up back in the 3's for my SWR because of a "SHORT" antenna. I made two more snips. The 1st snip I took off about 1/4 of a coil of wire. I saw a small change in the SWR reading. With the 2nd snip I took off another 1/4 of a coil of wire. My final SWR ended up being:

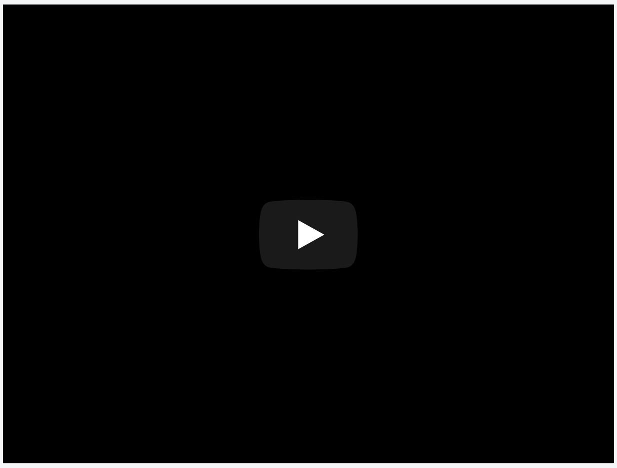
Channel 01: 1.05:1
Channel 20: 1.15:1
Channel 40: 1.45:1

I'm happy with those readings. During the tuning process, you may have noticed that channel 01 got down to a 1:1 SWR. On my last snip, it creeped back up to 1.05:1. I figured it was time to stop tuning, especially since the other two channels were both within spec now. It's nice to know that this antenna was very tunable and a tuner is not required to use it. I think the hardest part of this project was tuning the antenna without a helper. It took some extra time to climb into the attic, snip some of the antenna, climb out of the attic, check SWR reading, climb back into the attic... I probably did that 5-6 times. I think my patience paid off though.

Long Distance Exchange (DX) And Local Talk Results

I'm in Ann Arbor, MI, USA. Over the last couple of days, I've heard 11 meter DX from Illinois, the Carolinas, Georgia, Texas, New York, New Jersey, Minnesota, Michigan, Ontario Canada, Ohio, Tennessee, Alabama, West

Virginia, and Florida. Unbelievable to me, and very exciting! All from a home grown antenna built from mobile antennas and mounted inside my attic. How cool is that? When the DX isn't active, I'm able to talk locally up to 3-4 miles. Here is a video showing some of the DX I've heard:



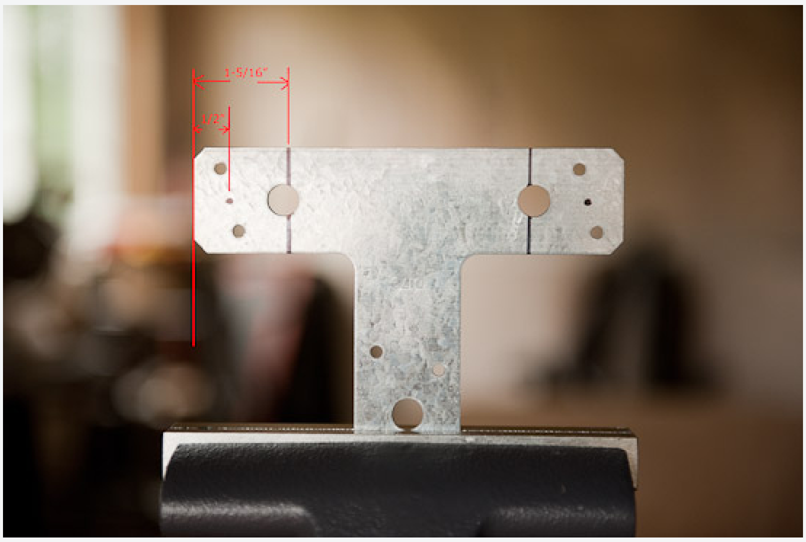
Antenna Assembly

The antenna assembly was really straight forward. The only difference between my assembly and John's (KL7JR) were the holes I drilled for the antenna mounts. The antenna mounts I purchased must have been a little larger than what John used because there wasn't enough space for them to mount properly in the existing holes after bending the Strong-Tie "T". If you choose to use the existing 3/8" holes then you'll need to drill them out since they aren't quite large enough for the lip of the plastic spacer to fit properly. They need to be bored out to a 1/2" diameter. Lets get started...

Parts List:

QTY	ITEM
1	Simpson Strong-Tie "T" (Part #: 66T) - Purchased At Lowes
2	Firestik® KW4 4ft Antenna - Click Here
1	PL-259 L-Connector (Diesel Part#: 360-56201)
1	Plug To Lug Connection - Stud Mount (Diesel Part#: 360-53401)
1	Plug To Plug Connection (Diesel Part#: 360-53402 or 360-53403)

HINT: If you get the Strong-Tie "T" from the Lowes website, search for Simpson 66T. The other items on the list can be found at many CB shops, truck stops, or antenna accessory suppliers.



Step 1: Mark the locations for the new antenna mount holes, and the lines where you'll bend the Strong-Tie "T". See the image for measurements.

Step 2: Before drilling the antenna mount holes, take a center punch and punch a mark in the Strong-Tie "T" at the hole locations. This gives the drill bit something to bite into when starting the hole.

Step 3: Drill the holes where the antenna mounts will attach to the Strong-Tie "T". Make sure you use a 1/2" drill bit.

Step 4: You'll probably end up with some sharp metal burs after drilling your antenna mount holes. Just take a metal file and file them down.

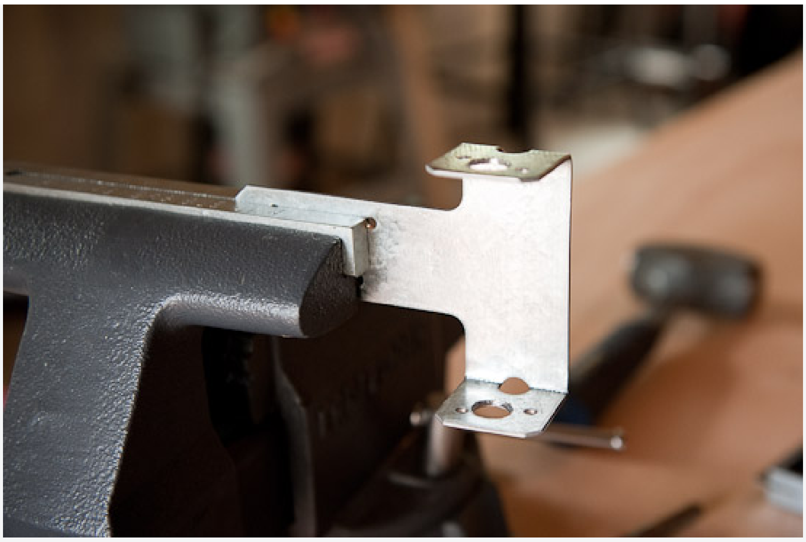
Step 5: This is what your Strong-Tie "T" will look like once you're done drilling the holes. Lookin' good! Next you'll be making the appropriate bends.

Step 6: Mount your Strong-Tie "T" in your vise so the top edge of the vise lines up with one of the lines you drew in Step 1. Once you're confident you have it locked tight in the vise, and square, then take your hammer (I used a 3-4lb hand sledge) and start hammering the bend into place. I started gently hammering near the black line to get it started. You may want to use your free hand to pull the top in the direction you're hammering too. Once you get it started you'll be able to hit it a bit harder. ***NOTE:*** John (KL7JR) says, "If you don't have a vise, you can use the rear bumper on your truck and a hammer to shape the Strong-Tie 'T' like he did." Hi-hi!

Step 7: Keep hammering until you have a 90° bend.

Step 8: Flip the Strong-Tie "T" around and line up the other line just like you did in Step 6. Hammer away!

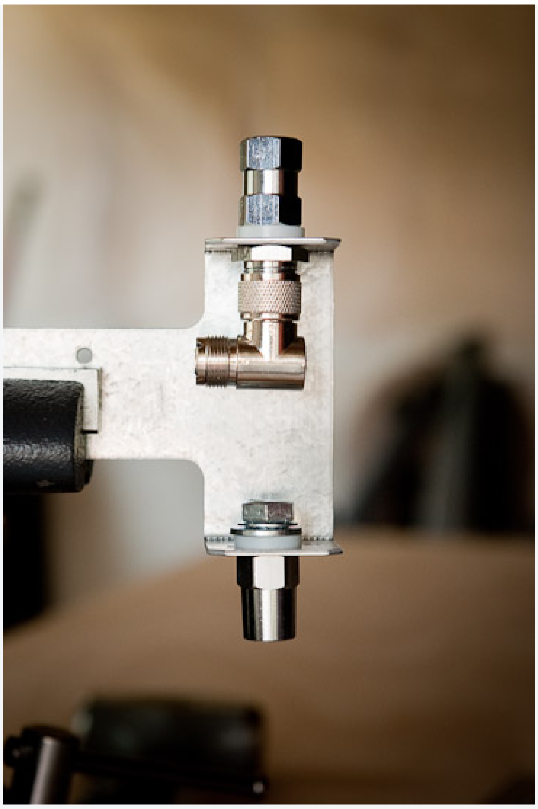
Step 9: Keep hammering until you have a 90° bend.



Step 10: The completed Strong-Tie "T" antenna bracket. Lookin' good!

Step 11: Mount the antenna stud mount (Diesel Part#: 360-53401) to the lower portion of the bracket. The mount may come with two plastic insulator/spacers. You'll want to use only one of the plastic spacers (or none). Some part of this stud mount *must* come in contact with the metal Strong-Tie "T" bracket. This antenna will be the "cold" antenna (see Step 12 for an explanation).

Step 12: Mount the "plug to plug" antenna mount (Diesel Part#: 360-53402 or 360-53403) to the top part of the bracket. It's important that this mount be attached to the top antenna in a vertical dipole scenario. You'll want your coax to attach to the top antenna. It's also very important that the plastic insulator/spacer goes between the bracket and the actual mount that the antenna will thread into. This will isolate the antenna from the bracket. John (KL7JR) said, "One of the antennas on the dipole (hot) is isolated from the mount and the other is not (cold). They are paired up with your center conductor on the coax (hot) and with the shield (ground-cold). For horizontal polarization, either antenna can be hot but for vertical polarization you want the top hot."



Step 13: Mount the PL-259 L-Connector to the "plug to plug" antenna mount (Step 12). That's it for the bracket. You'll now need to find a place to mount it (if you haven't already) and connect your mobile antennas. Hopefully you'll have a helper when dialing in your SWR.

Questions? Comments?
Email: scott AT wolfington DOT net
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http://www.wolfington.net/articles/dipole/default.html

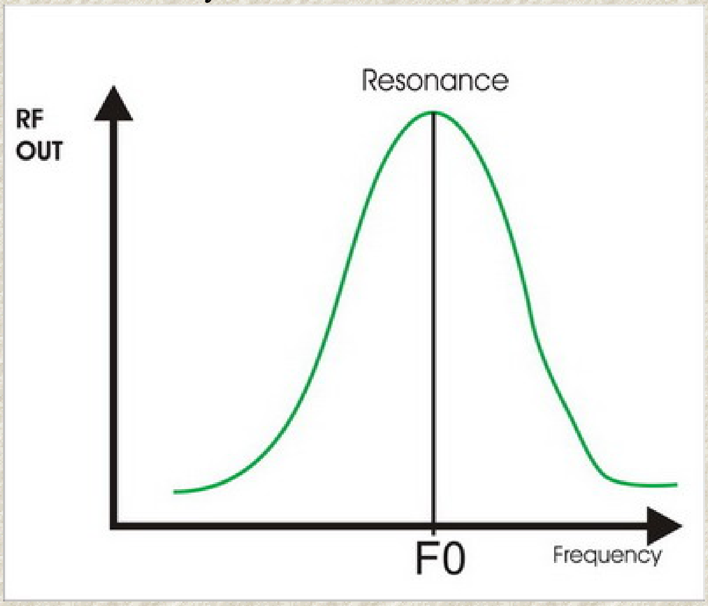
G3TSO Mobile Antenna Page

Some useful information for tuning mobile antennas gained the hard way!

Mobile Antenna

RF Output falls rapidly away from Resonance

1. To work efficiently the short mobile antenna must be resonant.



2. At the resonant frequency F0 the antenna generates the maximum voltage across the antenna and the maximum current through it, with the correct phase relationship. Efficiency drops rapidly as you move away from the resonant frequency

3. Will an ATU resonate the antenna? **NO!**

4. Will an ATU change the antenna SWR? **NO!**

5. Will an ATU ensure maximum output? **NO!**

6. So what does an ATU do in a mobile installation?

It can fool the transmitter and the operator, but not the antenna!

7. Most amateurs have become used to tuning for a minimum indicated SWR. This is meaningless in a mobile installation. WHY? An efficient mobile whip is unlikely to be 50 ohms. An inefficient one may be! Minimum SWR is NOT an indication of maximum radiation; it simply means the tuning device has found a point where it thinks the antenna exhibits 50 ohms but, to achieve this the voltage and current will not have the correct phase relationship for optimum radiation.

8. The only sure way to tune an antenna is to change its physical characteristics.

9. Once the antenna has been resonated at the operating frequency, an ATU can then be used as an Impedance Transformer.

10. If the loading coil is placed at the top of the antenna, the RF current flows through the entire length of the antenna, giving rise to the highest radiation efficiency for a given antenna length. On the

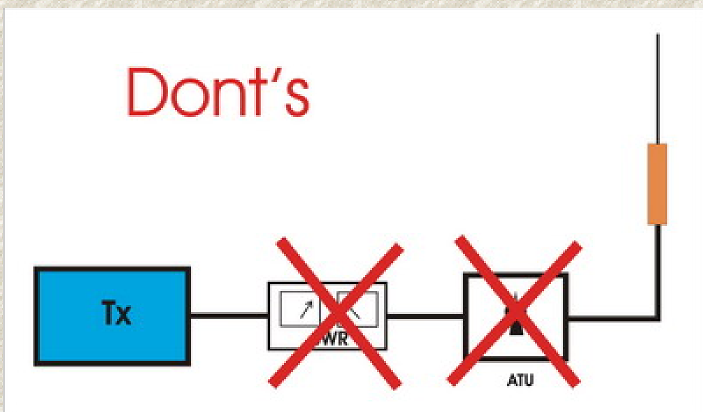
negative side, raising the inductor reduces the capacitance to ground, with the result that more turns are required on the coil to resonate the antenna. Unless heavier gauge wire is used, the DC resistance of the coil will increase raising the base impedance but reducing the overall efficiency. Top loaded antennae may be difficult to manage mechanically in a mobile installation and may be more suited to fixed base operation. An interesting characteristic can be observed by increasing the length of antenna below the loading coil on a LF mobile antenna. Raising the coil also results in a reduced capacitance to ground causing an increase in F0 rather than decreasing it as one might expect with a longer overall antenna length. In effect if you increase the length of the base mast, it will also be necessary to increase the top section capacitance to bring the antenna back to resonance.

11. If the loading coil is placed at the base of the antenna it is mechanically more stable, making design simpler, especially for multiband operation;. The inductance values required are lowest minimising any resistive losses however; the radiation efficiency is low because there is little or no length of antenna carrying RF current. Typical ATAS and Screwdriver types (Jack of all trades but master of none!).

12. The Centre (or slightly above centre) loaded whip provides a good compromise achieving an optimum L-C ratio, mechanical stability, and good radiation efficiency. This type of antenna is usually confined to single band operation; the Hustler remains one of the best commercially available. The Webster Bandspanner dating from the 1960s was a commercially made multiband antenna with remote adjustment of the inductance.

13. Helically wound antennae made from a continuously wound coil may offer greater mechanical stability compared to a centre loaded whip of the same length however: the radiation efficiency is comparable with a centre loaded whip of similar length. Helicals are typically monoband however, G-Whip offered a three band helical employing a slide switch, and a removable top section. The base impedance of this antenna was typically 17 ohms on 28 MHz resulting in an indicated SWR of around 3:1 at resonance.

14. Low resistance grounding at the antenna base is essential for optimising performance as well as minimising noise and RFI. In a short vertical antenna the Earth current = Antenna current. The location of the antenna should take into account the presence of a good earth consequently, bumper mounting may result in better performance than roof mounting where obtaining a good RF earth may prove difficult. Mag mounts which provide no grounding at all may give rise to earth currents circulating in the feed cable!

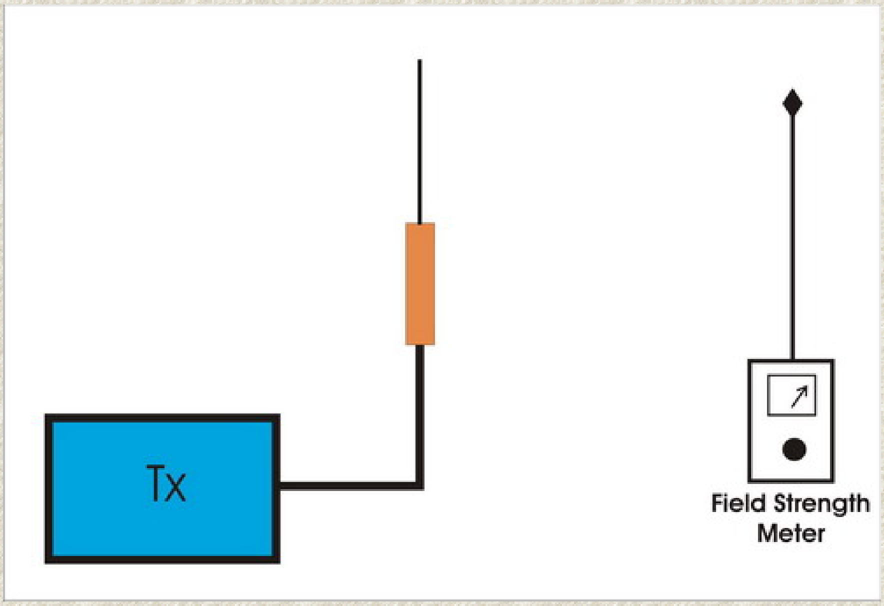


Do's ADJUSTING and MATCHING A MOBILE ANTENNA

1. DETERMINE APPROX FREQUENCY OF ANTENNA by using:

a) Receiver Noise Level
b) Grid Dip Meter

2. APPLY SIGNAL SOURCE (Low PWR Tx)Sweep across required Band

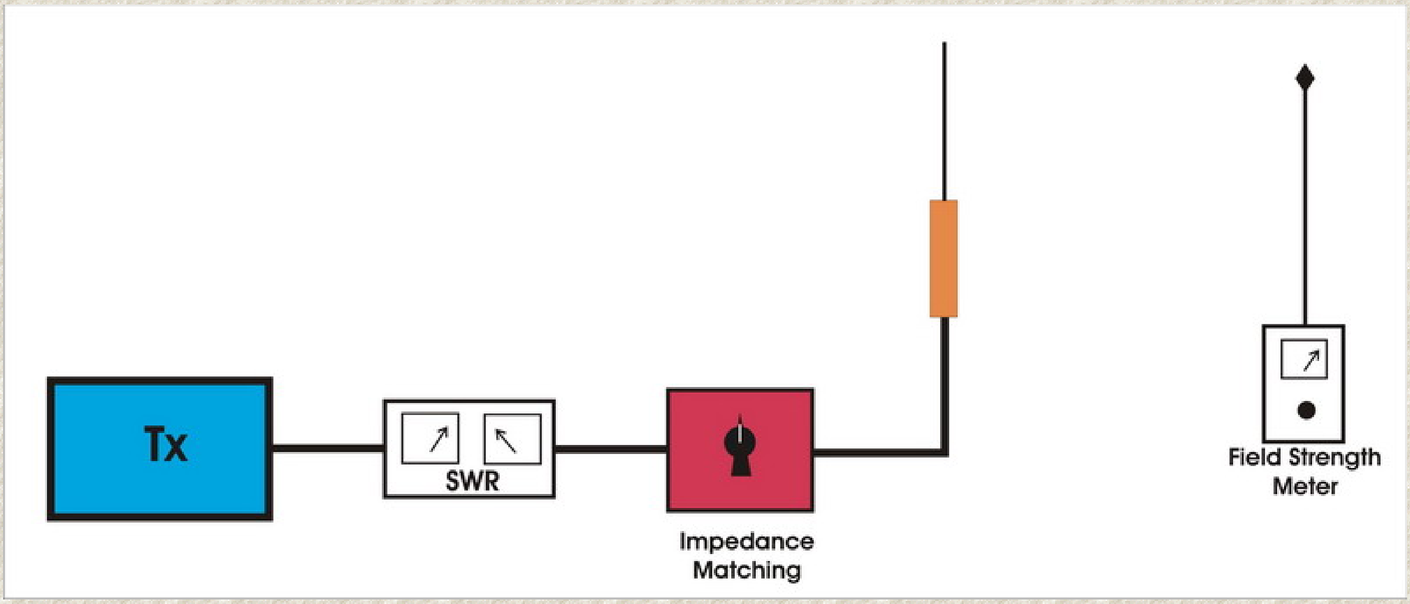


3. Note "PEAK" on FS Meter (Distance >6ft) Maximum radiation.

4. ADJUST ANTENNA LENGTH to move "PEAK" to desired operating frequency.

5. CHECK MAX RF OUTPUT on desired frequency (FS meter).

6. CHECK SWR - Min SWR will not coincide with max field strength, may be as high as 3:1 at resonance



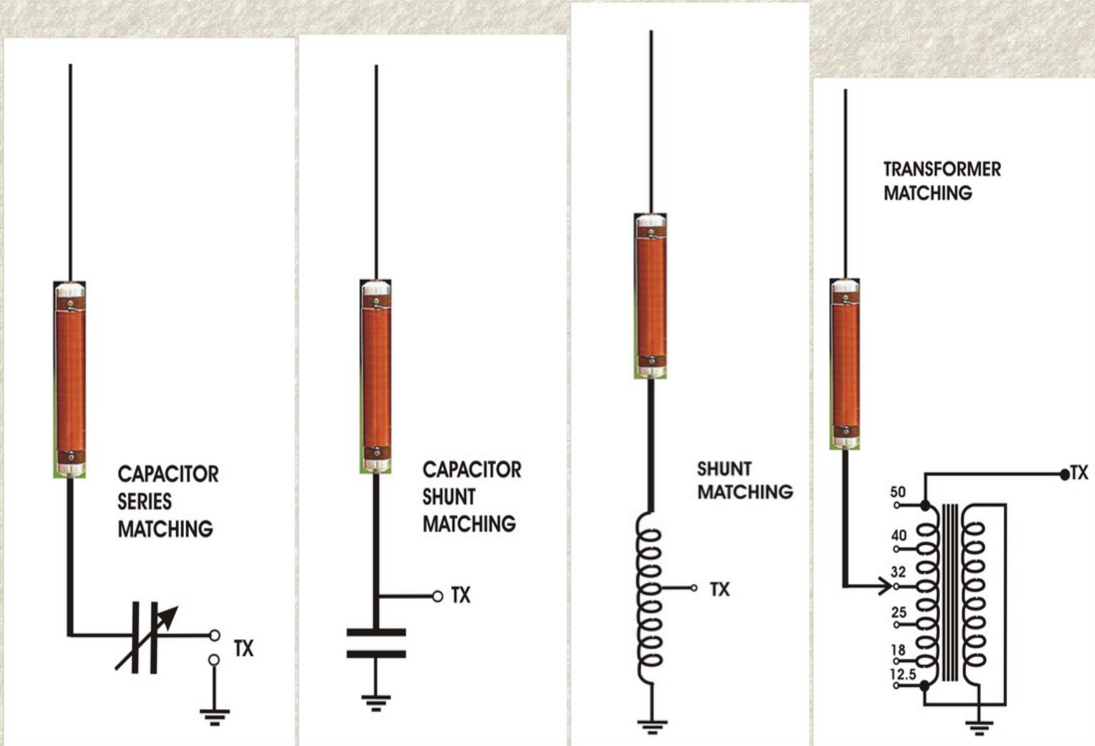
7. MATCH BASE IMPEDANCE to reduce SWR (ATU, AMU, Transformer etc)

8. Re-CHECK RESONANCE (FS Meter)

9. Make a Calibration Chart for adjusting the antenna length; it can be critical to 1/16th inch.

Note: When the antenna impedance is correctly matched, the min SWR at the transmitter may also coincide with the resonant point i.e. Min SWR will now occur with maximum output and may be used as an indication of Resonance. To CHANGE FREQUENCY, ADJUST THE ANTENNA, NOT THE MATCHING UNIT

METHODS OF FEEDING A MOBILE ANTENNA



1. Capacitor series match allows some pulling of antenna frequency - single band operation

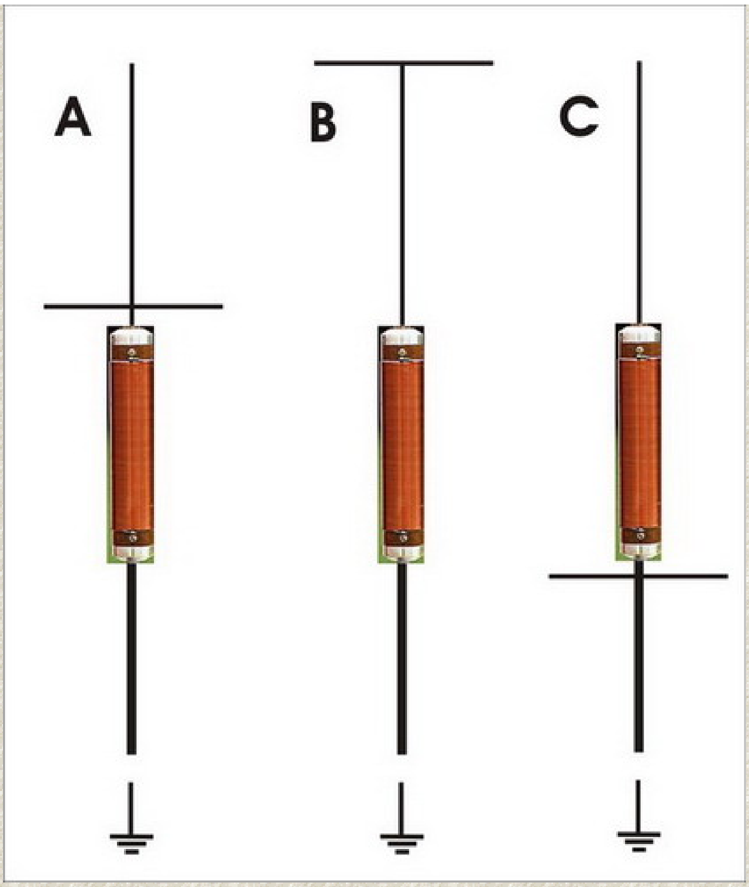
2. Capacitor shunt match OK for LF single band operation

3. Inductive shunt more suitable for higher frequency single band operation

4. Transformer match allows easy multiband operation for antennas between 12.5 and 50 ohms..

5. Do not try to tune the antenna with the transformer! Change the length of the antenna.

Capacity Hats



1. In Case A the hat is located just above the loading coil; this increases the capacitance to ground resulting in a lower value of inductance reducing resistive losses. The hat may take the form of an adjustable tuning element. Fairly common in the 1960s, but disappeared in later years. Little or no improvement in antenna performance.

2. In Case B the hat is placed at the top of the antenna; like top loading, it is designed to increase the current flow in the upper part of the antenna; top hats make the antenna unsuitable for mobile operation but can improve antenna performance.

3. Case C is a curious arrangement that has been observed in some CB antennas; whilst it might look impressive, adding capacitance below the inductor serves no useful purpose.

Transformer Schematic

TYPICAL PERFORMANCE FIGURES

FOR CENTRE LOADED MOBILE WHIP

(9ft on LF Bands - 6 ft 6ins on HF Bands)

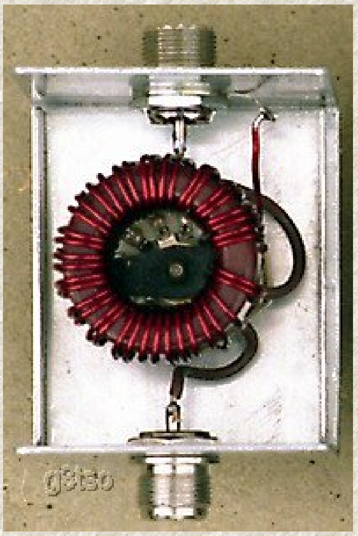
Transformer Matching Unit

Band	Ant Length/ Wavelength	Approx Gain db (or loss)	Radiation Effy %	Tx Pwr	ERP
160	1/57	-26	0.25	32W	80 mW
80	1/29	-20	1	100	1 W
40	1/15	-14	7	100	7 W
20	1/10	-10	10	100	10W
15	1/7	-6	25	100	25 W

10	**1/5**	**-2**	**63**	**100**	**63 W**

Note: Base loaded antenna will be worse and top loaded marginally better. As the antenna moves away from resonance or if lower quality coils are used the figures may be considerably worse.

50 - 12.5 ohms



[See also GM3VLB Web page]

Back

HOME

Four types of Homebrew 12/20/30 Ampere 13,8volt power supplies: RE PSF14A12D, PSF14A20D, PSF14A20 and PSF14A30

RE-PSF14A12D

revision 4

By Guy, de ON6MU

This is an easy to make power supply which has stable, clean and protected output voltage. The overal dimensions can be kept (relative) small by using TO220 darlington BDX-33 transistors. Using 3 BDX-33 darlington transistors is almost 3 times the amount of amps then the power supply delivers, making it real though to brake ;). Although you could use this design to deliver 20 amps (with almost no modifications and with a proper transfo and a huge heat sink with a fan), I did not needed such much power. Second reason was the size of the alu box I happen to have spare HI. There was simply not enough room for the transformer, and surely not enough space to mount a huge heat sink, as the BDX33 transistors can get very hot, and they do not like that so much.
It is obvious, but I would like to mention that you could make this power supply with less BDX-33 transistors if you do not need high power.

Although the 7815 power regulator should kick in on shortcircuit, overload and thermal overheating, I build in a very simple secondary overvoltage protection that's made out of 12 volt relay. The rectified voltage of: 15 volt x SQR2 = 15 x 1.41 = 21.15 volt measured on C1. This is the voltage that could be on the output if one of the transistors should blow. We need a little calculation to get the exact voltage (or higher) to power the 12volt relay which should disconnect the output. In this example we use for diode Zd 9v/5watt -> 21v - 9v = 12 volt. To allow the relay to disconnect the output on lower voltages, use a lower voltage for diode Zd. You could use a different voltage relay too, but diode Zd should be calculated to allow the relay to work just when the output voltage rises over 16 volt + (Zd in the schematic).
Remember that the relay needs to be able to switch 12 amps (or more). If the relay offers multiple switches then please use them. The more the better (also less resistance hence voltage drop when loaded).

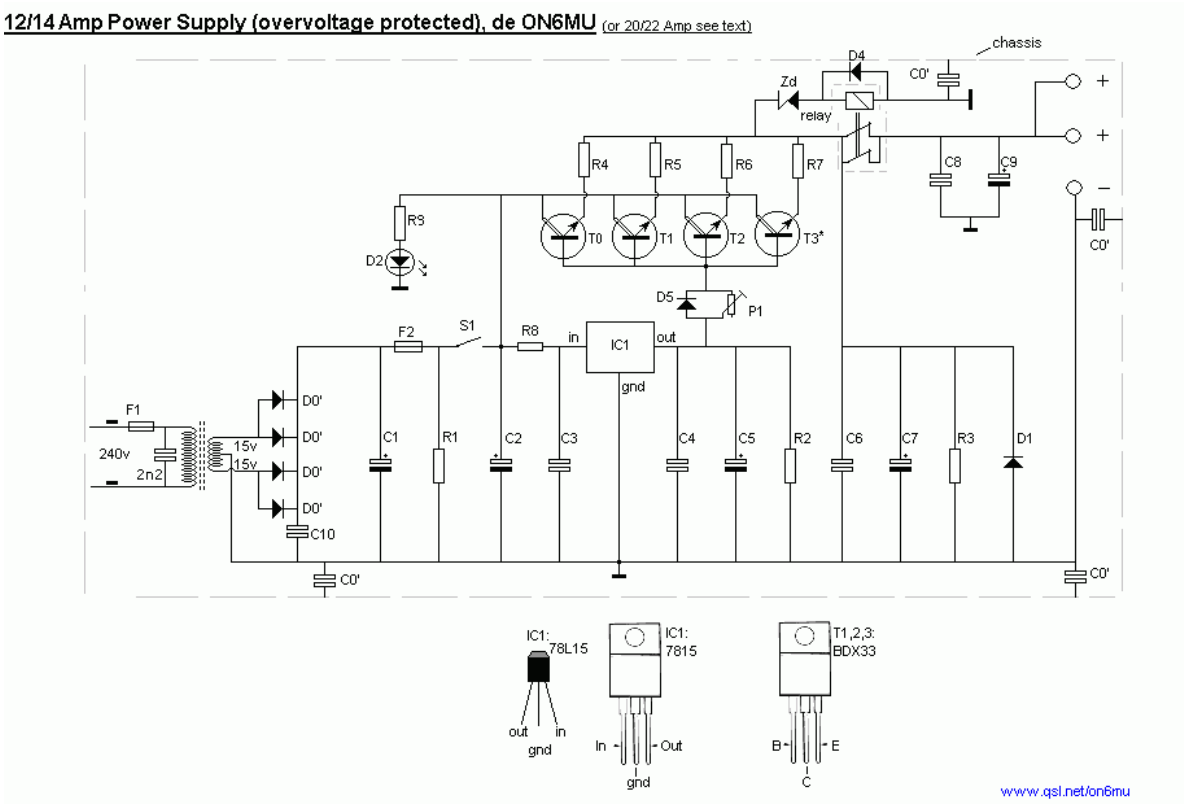
P1 allows you to 'trim' the output voltage exactly to 13.8 volts.

Remember to isolate the transistors from the chassis/radiator! This is very important! Use a radiator (heat sink) of appropriate size and surface area; insulating and heat-conducting spacer or at least a thin mica; hot adhesive and thermal paste. Use thick wires.

Just to be sure to prevent HF entering (or going back to the mains) use a ring core to turn the mains a few times around it (see insides pics).

Revision 3
. Zd was wrongly connected after the relay switch instead of before
. C5 changed to 330uF to improve ripple rejection and stabelisation
. primary side of the transformer added 250v/2n2 decoupling cap
. P1 = 500Ohms or 1k trimmer is sufficient
. reversed diode over IC1 removed

RE-PSF14A12 Power supply Schematic 1



Part list PSF14A12D
12 Amp BDX33-based power supply:

- 2 x 15 volt 6+ amps
- 2 times two MR750 (MR7510) diodes (MR750 = 6 Ampere diode) or 2 times 3 1N5401 (1N5408) diodes.
- F1 = 1,5 (2) Amp
- F2 = 15 amp
- R1 2k2 1 Watt
- R2 10k
- R3 1k 0.5 watt
- R4,R5,R6,R7 0.1 ohm 5 watt
- R8 4.7
- R9 6k8
- C1 two times 4700uF/35v
- C2,C5 330uF/35v (revision 2: C5 = 330uF -> improved ripple rejection and stabelisation)
- C0',C3,C4,C6,C10 100nF
- C7 330uF/25v
- C8 47nF
- C9 47uF/25v
- D1 1N5401
- D2 LED
- D4, D5 1N4001
- IC1 78L15
- relay 12 volt 2x5 amp switching
- 3 darlington transistors: T0,T1,T2 = BDX-33 NPN TO-220 transistor
- Zd 8 or 9 volt, 5 watt

- P1 1k trimmer

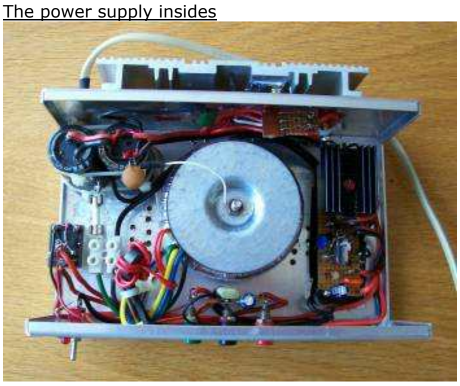
If using a bridge rectifier (like in schematic 2) you do not need 2 x 15 volts 6 amps, but 1 x 15 volt 10+ Amps

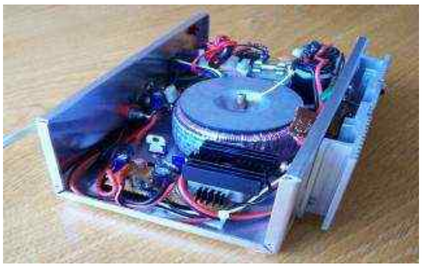
Part List PSF14A20D
20 Amp BDX33-based power supply:

- 2 x 15 volt 12+ amps
- 2 times 3 MR750 (MR7510) diodes (MR750 = 6 Ampere diode) or 2 times 5 1N5401 (1N5408) diodes.
- F1 = 3,18 Amp
- F2 = 25 amp
- R1 2k2 1 Watt
- R2 10k
- R3 1k 0.5 watt
- R4,R5,R6,R7 0.1 ohm 10 watt
- R8 4.7
- R9 6k8
- C1 22000uF/35v
- C2, C5 330uF/35v (revision 2: C5 = 330uF -> improved ripple rejection and stabelisation)
- C0',C3,C4,C6,C10 100nF
- C7 330uF/25v
- C8 47nF
- C9 47uF/25v
- D1 1N5401
- D2 LED
- D4, D5 1N4001
- IC1 7815
- relay 12 volt 10 amp switching
- Four darlington transistors: T0,T1,T2,T3 = BDX-33 NPN TO-220 transistor
- Zd 8 or 9 volt, 5 watt
- P1 2k trimmer

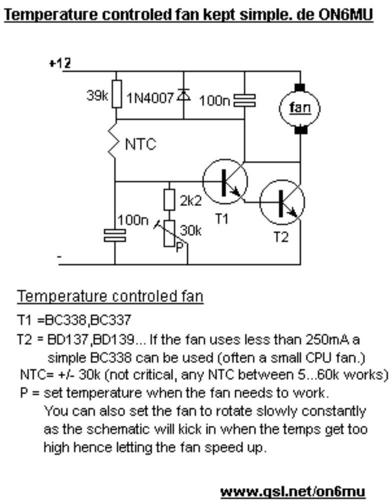
If using a bridge rectifier (like in schematic 2) you do not need 2 x 15 volts 12 amps, but 1 x 15 volt 20 Amps

The power supply insides



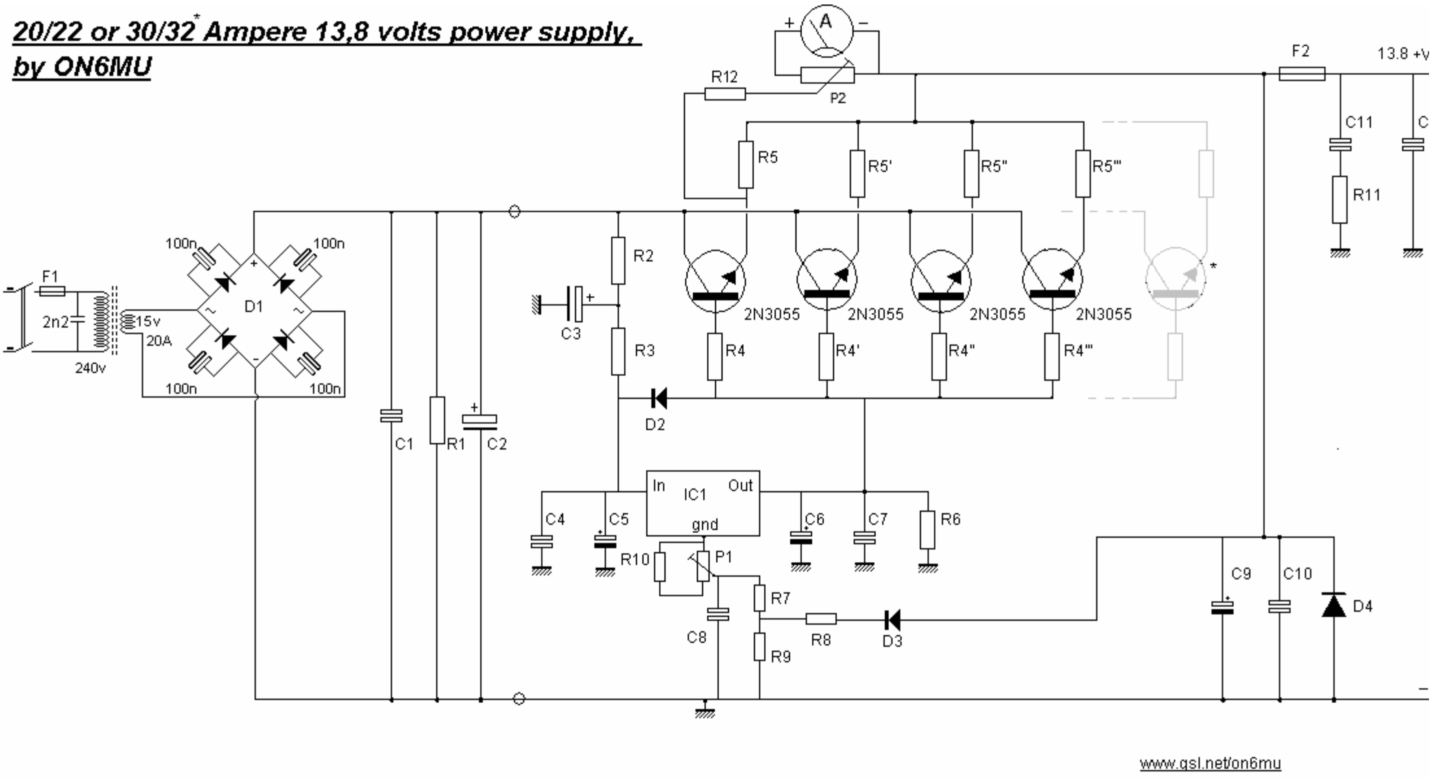


A simple temperature controled fan:



20/22 Ampere or 30/32 Ampere 13.8 volts power supply
RE-PSF14A20 or PSF14A30
de ON6MU

RE-PSF14A20
Power Supply Schematic 2 (new design) revision 2014



Remember to isolate the 2N3055 transistors from the chassis/radiator! This is very important! Use a radiator (heat sink) of appropriate size and surface area; insulating and heat-conducting spacer or at least a thin mica; hot adhesive and thermal paste.

PSF14A20 Specs

- Heavy duty power supply 13.8 volt, 20 or 30 amps continue
- low ripple
- short-circuit protection
- HF-immunity
- Voltage can be set between 12,3 and +/- 15 volts
- only 0.35v drop at full load
- parts widely available and calculated way over the maximum load

PSF14A20 Parts **(30 amp version PSF14A30 in blue)**

- transformer capable of delivering 20 amps @ 15volt (30 amps)
- 4 x 2N3055 (6 x 2n3055) (you can also use the 2N3773 transistor)
  Use a large radiator (heat sink) of appropriate size and surface area; insulating and heat-conducting spacer or at least a thin mica; hot adhesive and thermal paste.
- IC 1: 7812 (small heatsink)
- D1: MB2504 is used as it is a 25 ampere rectifier bridge and should also be very good cooled.
  Or you could use 3 times four BYW29 8 amp diodes (TO220 pinning, cooling).
- D2 & D3: 1N4001 or simular
- D4: 1N5401 or simular (1N5400...1N5408)
- C1: 47nF
- C2: 22000uF (+ 10000uF) 35volts
- C3: 100uF/35volt

- C4: 100nF
- C5: 4.7uF/35volt
- C6: 4.7uF/35volt
- C7: 100nF
- C8: 220nF
- C9: 220uF/25volt
- C10: 47nF
- C11, C12: 100nF
- R1: 2k2 / 1W
- R2: 10 1/2W (2,2 1/2W)
- R3: 6,8 1/2W (2,2 1/2W)
- R4': 1 Ohm 1/2W
- R5': 0.1 Ohm/5W
- R6: 2k2
- R7: 10
- R8: 2k2
- R9: 22
- R10: 1k5
- R11: 10
- R12: 220
- P1: 1k
- P2: 2k2 trimmer (to calibrate the meter that will be used to measure the amps)
- F1: 2A (3.18A)
- F2: 22A (35A)

P1 allows you to 'trim' the output voltage exactly to 13.8 volts.
Just to be sure to prevent HF entering through the mains use a ring core and turn the mains a few times around it (see insides pics).
Be sure to use thick braid wires!!! They need to handle 20 (30) amps continues!

Total revision changes:

. highly improved voltage stabilisation
. output voltage feedback circuit stabilisation
. BDX-33 removed
. Cap after 7815 changed from 1uF to 4.7uF
. Resistors before the input of the 7815 changed
. reverse diode (between collector and emitter of 2n3055) removed
. voltage can be set exactly to 13.8v (P1)
. minor HF-immunity changes
. reversed diode over IC1 removed

Revision 2016:

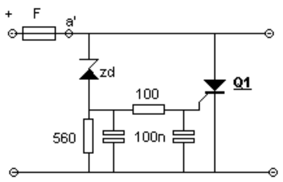
. R10 changed 1k5, and P1 to 1k (thanks Goran 9A6C)
Goran reported that he could not reach 13.8 volts using a 500 Ohm potentiometer(P1) parallel with the 1k resistor(R10).
Replacing P1 & R10 with fixed resistor of 680 Ohm would give approx. 13.6 volts.

. Revision 2017: added ampere meter without using the meter in series (P2 trimmer to calibrate the meter that will be used to measure the amps)

Overvoltage protection:

A crowbar circuit is an electrical circuit used to prevent an overvoltage condition of a power supply unit from damaging the circuits attached to the power supply. It operates by putting a short circuit or low resistance path across the voltage output (Vo), much as if one were to drop a crowbar across the output terminals of the power supply. Crowbar circuits are frequently implemented using a thyristor, TRIAC, trisil or thyratron as the shorting device. Once triggered, they depend on the current-limiting circuitry of the power supply or, if that fails, the blowing of the line fuse or tripping the circuit breaker.

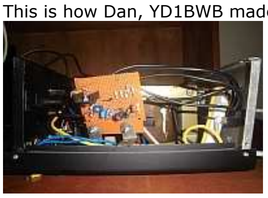
The 'CROWBAR' overvoltage protection circuit (RF blocked)



Zd = zener xx Volt - maximum voltage to allow. For 12v PSU use Zd of 15v or 16v
Q1 = thyristor powerful enough to peak surge the current that the power supply delivers (times 10) hence blowing the fuse. Example:BTW69-600 (peak 600 Amp!)
Important: Be sure the power supply has a correct fuse!!

Pictures of people who made the PS

This is how Dan, YD1BWB made it:





click on the images to enlarge

Thanks Dan!

Links of interest:

ON6MU Homebrew projects
Radioamateur related projects
ON6MU 78h05 powersupply
Versatile 7805 based 5Amp powersupply

Home
www.qsl.net/on6mu

ON6MU

ON6MU

Magnetic longwire baluns 1:9

combined with ground, a 1:4 and 1:1 balun connections

RE-ABU1HF

By Guy, de ON6MU

About the MLB (magnetic longwire balun RE-ABU1HF)

This Magnetic Longwire Balun (MLB) makes it possible to efficiently use a coaxial lead-in cable with all forms of longwires, T-forms or other types of wire antennas, without the need for an antenna tuner. A very low loss magnetic transfer of energy from the antenna to the receiver is accomplished and static noise is reduced. Your coax is much less susceptible to interference. You can even connect a dipole to it.
It works fine with a heavy duty 41 foot (12.5 meters) wire, some nylon rope and a quality insulator. At the feed-line end the antenna is terminated with the Magnetic Longwire Balun. This balun permits an exceptionally low loss transference of antenna energy to your coax feed line. The result is significantly reduced static noise on long, medium wave and the shortwave bands.

You do not have to Earth/Ground the Green wire sticking out of the top, but it helps minimize interference if you do. Grounding the balun / coax (pin 3) to a good earth made between 3 and 6 dB improvement on noise and QRM, even though the station was well-grounded.
The key to getting good noise rejection from coax used to feed a longwire is grounding the coax shield well. It makes little sense to extend the coax beyond the farthest ground point from your receiver, since beyond that last ground point the coax would pick up signal anyway, despite its shielding. Thus, a low noise coax-fed longwire will typically fall within the spectrum ranging from verticals through tilted wires and inverted L's to Beverages (long, low, horizontal wires). This balun can smooth out the wild efficiency swings and also give static electricity a path to ground.

You could add a shoke inside (or outside) the balun housing to prevent even more from coax radiating too. A few feritte beads over the coax or turn a piece of 50 coax a few time around a feritte core. If possible inclose the shoke inside the balun housing or as close as possible to the SO239 connector.
Long-wire antennas are directional, so bend yours to allow both N-S and E-W orientation. Height is dependent on your location and surrounds … experiment!!

Pin 1 = 1:9 ratio for longwire (6...100m wire)

Between Pin 2 and Pin 3 = 1:4 balun

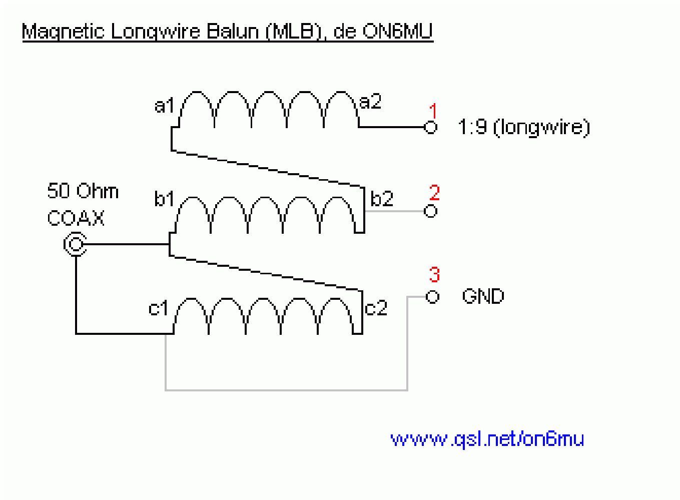
Between Pin 1 and pin 2 = 1:1 balun (dipoles)

You can use one of the bolts to mount your balun too.

If you do have an unknow toroidal core you would like to use, and you do not have the proper equipment to test it, there is a little experiment that can give you at least an indication of the frequency range of the core. So If you want to use other toroidal cores you will have to experiment with the number of windings and test it with a SWR/power-meter, field strength meter and a 450 ohm 1 watt carbon resistor (470 + 10k parallel) soldered between pin 1 and pin 3 (gnd). One SWR/power meter is connected directly to the coax output SO239 and with a field strength meter measure the radiated power at the resistor and check the SWR. Connect your transceiver and test on all bands (@ 0.5 watt).

Second method is using two SWR/power meters and a 50..70 Ohm dummy load. Connect the output of the SWR/Power meter on a dummy load and the output of the meter between pin 1 and pin 2. The second SWR/power meter is connected with a coax to the SO239 of the balun and your transceiver. Check input and output power and the SWR while transmitting on all bands (at low power!). You should see a power drop measured at the balun at non supported frequencies of the core. SWR reading can vary too as the frequency range of the core is lower or higher then the transmitted frequency.
The more turns you manage the better the bandwidth.
I have found that the lower frequencies If you use an Amidon T130-2 red toroid are not to good. To improve the balun on the lower frequency range (1...4Mc) we need to add as much turns as possible. I managed to put 11 turns of 1mm wire (see picture below) and has a very positive influence on the bandwidth, or I simply had a bad T130-2...

Schematic: Magnetic Longwire balun, with 1:1, 1:4 and 1:9 connections



MLB PVC watertight housing and building tips

 50 mm PVC tubes with watertight rings 

Can be bought in any DIY store. These PVC pipes are very ridgid, weatherproof and water tight! Plastic thickness is approx 2mm.

 balun connected to SO239 (for PL259 connector)

This where you connect your 50 Ohm coax to. SO239 connecter is sealed inside with glue and painted with graphite spray/paint. After glueing around the edges of the centre pin, paint a few layers of graphite over the connector and inside the ring which will ensure a good ground contact, prevent corrosion and further seal up the connector for any tiny openings where water could come in. Be sure not to paint the centre pin!!

 inside the balun housing

First solder the 3 antenna connections of the balun. There are 3 'outside' antenna connections needed. The middle for the connecting the longwire antenna (output nr 1 1:9), yellow left side wire for output nr 2 (1:2/1:1) and the black wire on the right for the ground output nr 3. Use innox, copper or galvanised bolts. Vernish, paint or glue at the inside of the pipe the bolts to seal them up and protect them against any corrosion.

If all is sealed up perfectly it should be watertight submerged under 1 meter water.

Parts list longewire balun

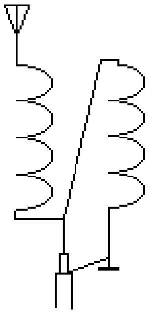
-  feritte core of 30mm, or Amidon T130-2 red or T200-2 red
  
  (or Philips 4C6 or 4C65 (pink color)
- 3 pieces of insulated wire (Cul) of 0,8mm...1mm (The more turns you manage the better the bandwidth. If you want to use other toroidal cores you will have to experiment with the number of windings and test it with an SWR-meter and a 450 ohm resistor (470 + 10k parallel))
- 3 x 30mm 5..6mm diameter weater resistant bolts (innox etc...)
- 50mm diameter PVC pipe (10cm) with two screwable waterproof tops
- SO239 connector

Specifications RE-ABU1HF

- Peak Frequency range: 100kc...30Mc (mostly depending on the core)
- Max. RF power CW: 100W (also depending on the core, the mismatch of the antenna and the transmission intervals)
- Max. RF power SSB: 200W (also depending on the core, the mismatch of the antenna and the transmission intervals)
- Output impedance to 50 Ohms
- 1:9 output for longwire
- 1:1 output for dipole usage
- 1:4 experimental
- protection against electrostatics

Appendix
1:4 Balun
bifilar coil nicely spaced over a red-amidon toroid will do fine

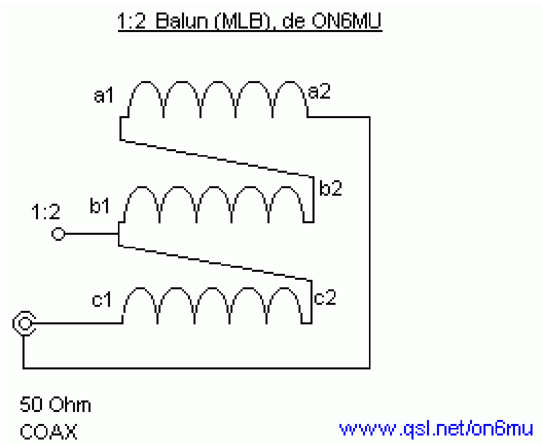
Just to make it complete, and if you just happen to need one, here is the principle schematic for a 1:4 balun only:



bifilar coil nicely spaced over a red-amidon toroid will do fine.

1:2 balun

And here is a 1:2 balun:



trifilar coil nicely spaced over a red-amidon toroid will do fine

Picture of my handy little QRP (low power) /A 1:9 balun

RE-ABU2HF

Same schematic as the 1:9 balun, but without GND and 1:1 / 1:4 output pin. Using a smaller core that fits snugly inside a 30mm PVC filmroll.

A core of 20mm should be fine up to approx. 20watt FM (40watt SSB), like the FT68-2 or FT80-2

Calculating the power dissiaption of the core: P = U2 / (Q . XL)

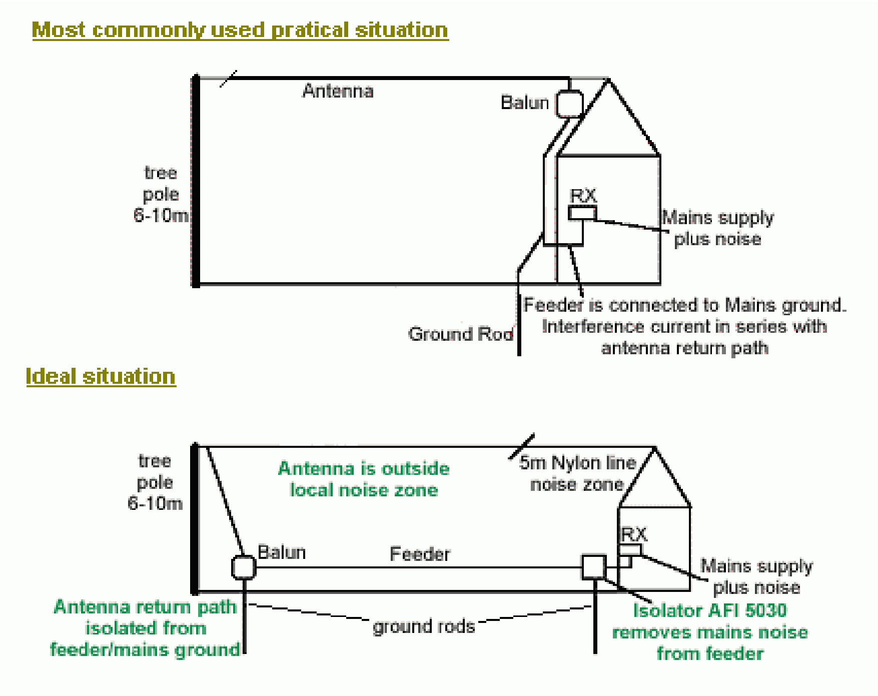
After testing glue the top part.

Seal everything.

For QRP or SWL purposes only you can use a Amidon FT50-2, FT50-43 or a T50-7

click here for details

Examples

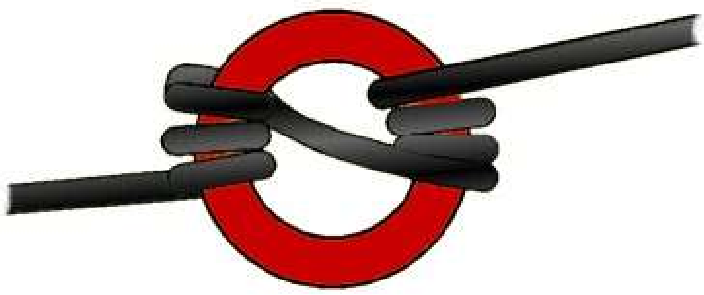


RF Choke to prevent hf currents on the feedline
(or...1:1 Choke Balun, sometimes called the "UGLY BALUN")

Ferrite beads hence chokes are used (in a way similar to inductors) as a passive low-pass filter. The geometry and electromagnetic properties of coiled wire over the ferrite bead result in a high impedance (resistance) for high-frequency signals, attenuating high frequency EMI/RFI electronic noise. The absorbed energy is converted to heat and dissipated by the ferrite, but only in extreme cases will the heat be noticeable.

Ferrite beads or coax turned over a ferrite bar are one of the simplest and least expensive types of interference filters to install on preexisting electronic cabling. For a simple ferrite ring, the wire is simply wrapped around the core through the center typically 5 or 7 times. Clamp-on cores are also available, which can be attached without wrapping the wire at all.

However, here we are using a toroid. Just turn 4 times on each side and opposite of each side a piece of RG-58 coax, like this:



 how it looks on an amidon red toroid

HF Choke finished

Choke coils are useful in a wide range of prevention of electromagnetic interference (EMI) and radio frequency interference (RFI) from power supply lines and such. Also prevents TVI from radiating feedlines.
You can add this to your longwire balun, antenna, or whatever needs preventing RF currents from the coax feedline...
Some use it as a 1:1 choke balun, called the "ugly balun".

Tip: use this choke after a longwire balun described above, or build it in the same container.

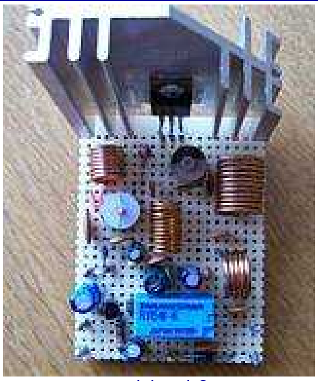
Another related project: [Magnetic longwire balun and VHF-splitter]

ON6MU

[Home]

ON6MU

Allmode RF Power Amplifier for the HF 15 and 17 meterband (21Mc/18Mc) RE-PA10HF17 and RE-PA10HF17



revision 1.3

By Guy, de ON6MU

About the 15- and 17-meterband HF amplifiers

This project and your efforts will provide you with a 0.55...3 watt input to easily 10 watt output. The two linear amplifiers are ment for use with QRP SSB/CW/FM/AM transmitters on the amateur bands 15 and 17 meters can be powered from a 12 volt DC supply. The design is a good balance between output power, physical size. The completed amplifier will reward the builder with a clean, more powerful output signal for a QRP rig when radio conditions become marginal. It has a RF-sensing circuit (Q2) wich allows the amplifier to switch on automatically when transmitting. This project uses a "classic" RF transistor. MOSFET power amplifiers are discussed and build in the near future on this website.

Bias
Power amplifiers used in base stations require biasing for proper RF performance. BIAS has be applied to Q1 to have clean proper and correct SSB modulation using this amplifier. Set P1 so +/- 35 mA current flows through Q1. Depending on the type of transistor this can vary somewhat, although you should never exceed 60mA! You don't need SSB? Read next part.

CW/AM/FM only
If you only want to amplify AM/FM/CW/FSK type of modulation (NOT SSB) then you can leave out the BIAS section for Q1 (between b1 and b2 in the schematic). You simply connect connection b2 to the ground, hence leaving out the somewhat critical setting of the correct BIAS for operating clean SSB.

Modulation modes
If using the schematic as displayed below and so also using Q1 BIAS, you can amplify any type of RF generated modulation waves.

Filter
RF purity and harmonic suppression is done here. Also allowing the transistor to be coupled to the antenna system through antenna impedance matching circuitry (C14). Care is taken at this stage so that no harmonic frequency is generated which will cause interference in adjacent band (splatter) on other bands. This 4-element L-type narrow bandpass filter circuit and a 3 element low-pass PII filter for the desired frequency cleans out any remaining harmonic signals very efficiently.

Housing/shielding
The whole circuit needs to be mounted in an all-metal/aluminum case. If you're unable to obtain an all-metal case, then use a roll of self-sticking aluminum tape (available from your hardware store) or PVC box painted with graphite paint. Just make sure that all individual pieces of aluminum-tape (or the graphite paint) are conducting with each other. Works fine.

RF-sensing

The basic principle of RF-sensing using a relay is clearly drawn in the schematic and pretty much self explaining. Q2 (BC338, 2N2222) will conduct when RF energy is applied at the input of the amp (and so also via C18, D3, D5 biasing the base of Q2) hence powering up a RF capable relay. This relay switches between RX and TX with amp. When no Vcc is applied to our amplifier (and so Q2 too) no amplification is done. The input is simply re-directed directly to the output (as if your transceiver is connected without an amp). The RF sensing circuit is sensitive enough to react on .5 watt easily.
To allow the amplifier in SSB-modulation some extended PTT time-on the RF-sensing unit (Q2->relay) has to be increased. This is done by closing S1 (SSB/FM) and so C20 adds the needed "breathing" time. In FM/CW/AM/FSK modes a carrier is present and extended PTT time-on of the amplifier isn't needed, hence can be short.
Important: timing can vary on the type of relay used (Ohms resistance value of the relay coil), so often experimentation of C19 & C20 is needed.

An error in the schematic previous to rev. 1.3 connected the input of the rf-sensing circuit wrongly to C10, instead of the input PL259 connector IN.

Important: Everything will be within specs if you use RY5W relay, but timing (the "breathing time") can vary on the type of relay used (Ohms resistance value of the relay coil), hence experimentation of C31 is needed.

Note:
Although this example of RF-sensing isn't the Worlds most best sollution, it is pretty easy for beginners though. Better would be to drive t2 from your transceiver (amp drive) as this will switch at the very moment of PTT.

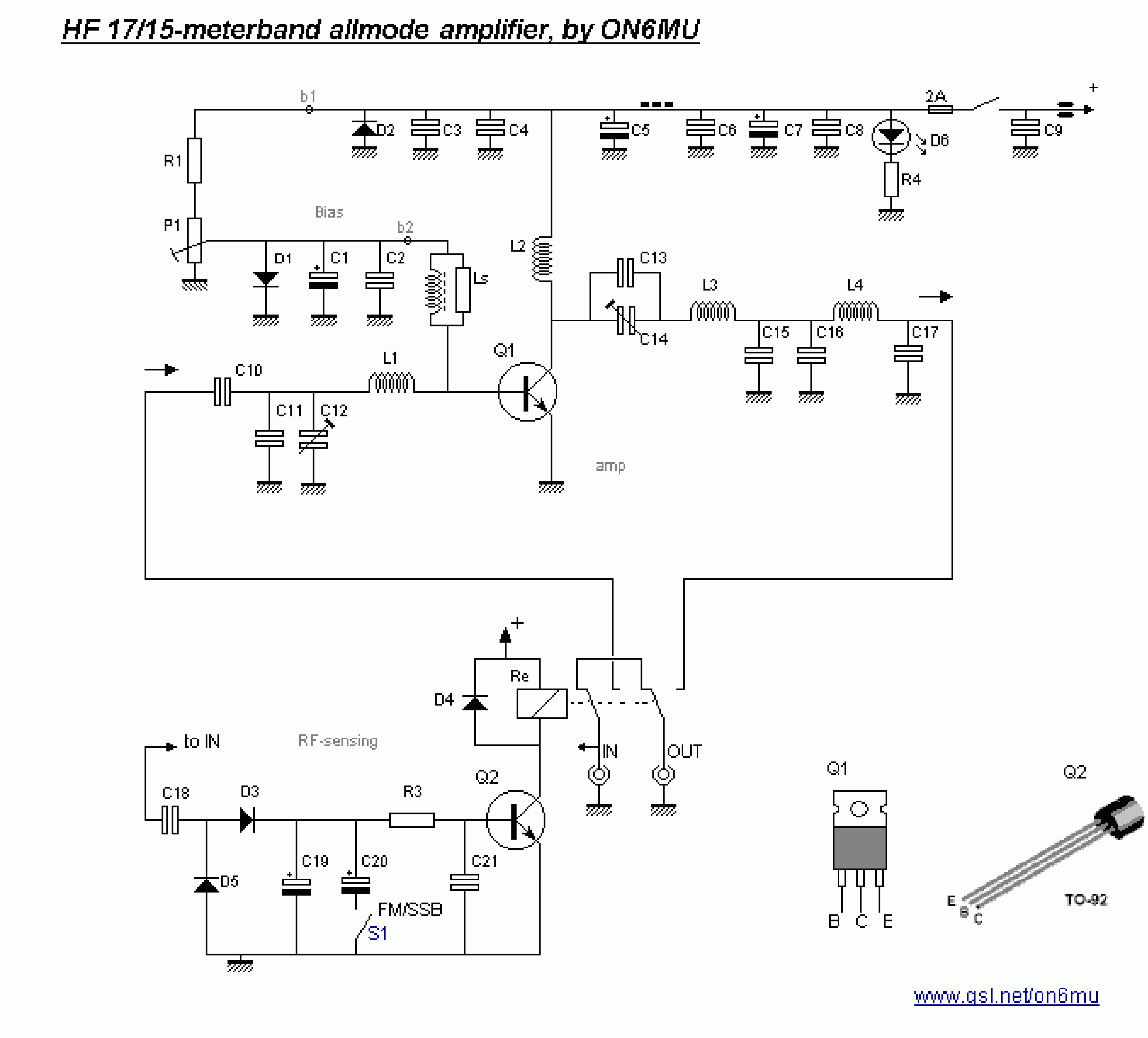
RE-PA10HF17: 17-meterband Amplifier settings

First set C12 and C14 to the middle and centre pin of P1 to the ground. After carefully mounting all parts and using as short as possible connections between the parts, gently add voltage to the amplifier while checking the current. The only current you should see is a the liddle idle current of Q1 (and LED D6 if connected). Increase the voltage to 12 volts. Check current again. It should (at this stage) be lower then +/- 20mA.

Now gently turn P1 till you get approx. 35 mA. Do not forget to mount Q1 on a heat sink isolated electrically from the transistor.

So far so good? Now we check if the (Q2) RF-sensing circuit is working properly. Connect a proper dummy load and a power meter to the output of the amp. Remove any connectors from your power supply and temporary disconnect the collector from the VCC. Connect your transceiver to the input. Be sure you set your tranceiver's power to minimum (never more then 3 watts) and you set your transceiver to 18.100Mc in CW/FM. Key your transceiver and if all goes well the Relay should power up and you should see the current rise and your power meter should already show an amplification of the RF input power.

Still all working as planned? Excellent! Now carefully turn C12 till you get maximum output power (whilest checking the input SWR on your transceiver or SWR meter). And finally tune C14 to maximum power. If needed re-tune C12 and C14 till you reached the maximum. Current should be around 1.2 Amp +/- (depending on the voltage and input power).

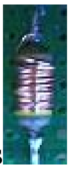


Parts list 17-meterband power amplifier

- Q1 2SC1969 (only Mitsubishi type!!), ERF-2030, 2SC1173, 2SC1944, 2SC2075
  (with proper heatsink isolated from the transistor)
  Note: There are reports I've read on various web sites about counterfeit components especially RF transistors, so be careful in buying huge lots. For example: I know that the 2sc2075 marked with a T works while others not?!
- Q2 BC338, BC337, 2N2222
- C1 1uF/25v
- C2 22nF
- C3 10nF
- C4 560pF
- C5 22uF/25v
- C6 47nF

- C7 100uF/25v
- C8 1nF
- C9 100nF
- C10 68pF
- C11 180pF
  (Stan 9H1LO reported using a 270pF instead of 120pF (rev1.2c 180pF) prevented the amp from oscillating in 24mc, probably do to differences in transistors and PCB)
  (Peter DL6NL reported using a 200pF which allowed 1:1 SWR)
- C12 6...40pF set at half position and tune to max power and best input SWR
- C13 68pF
- C14 6...40pF set at half position and tune to max power on 50 Ohm dummyload
- C15 120pF
- C16 47pF
- C17 180pF
- C18 10pF
- C19 2.2uF/25v
- C20 68uF/25v
- C21 100nF
- R1 1k5 (revision 1.2)
- R3 1k5
- R4 1k
- P1 5k (revision 1.2) pot. to set BIAS for correct SSB operation +/- 35mA@13.8v
- D1 1N4148 (revision 1.2)
- D2 1A si diode 1N4001, 1N4005
- D3,D4,D5 1N4148
- D6 LED
- Re = 12volt relay with silver plated contacts and low RF capacitance with 2times 3pole switch: RY12W-K
- L1 = 1mm CuI (insulated copper wire), 7 turns close together, 7mm inside diameter
- L2 = 0.6mm CuI (insulated copper wire), 14 turns 0.5mm space, 7mm inside diameter
- L3 = 1mm CuI (insulated copper wire), 11 turns close together, 10mm inside diameter
- L4 = 1mm CuI (insulated copper wire), 5 turns close together, 10mm inside diameter

- Ls = 470 1/2 watt carbon, 0,2 Cul turned 3 times over the entire length of the resistor
- Ferrite bead 3 turns wire inside
- S1 switch open = AM/CW/FM/PSK/PKT, switch closed = SSB

Ls 

Note:
Always use a dummy load for testing and adjusting the amplifier!!!

Specifications RE-PA10HF17

- Peak Frequency range: 18Mc...18.5Mc
- Output RF power: at least 8W @ 13.8v - 12W@16v
- All modulation modes
- Adjustable output impedance to 50 Ohms
- Adjustable input impedance to 50 Ohms
- High efficient band-pass type harmonic L-filter + lowpass PII filter
- PII-filter at input
- Usable voltages: Vcc 10 - 18 volts
- Average current I: +/- 1A @ 14 v
- RF-sensing
- VSWR overload resistant (not infinite)
- Can be used without complex BIAS if only needed for CW/AM/FM/FSK type modulation

How **Peter DL6NL** made it!
Click image to enlarge

RF Power transistors:

2SC1969/ERF-2030

Features:

- High Power Gain: G_{pe} >/= 12dB (V_{CC} = 12V, P_O = 16W, f = 27MHz)
- Ability to Withstand Infinite VSWR Load when Operated at:
  V_{CC} = 16V, P_O = 20W, f = 27MHz

Application:

- 10 to 14 Watt Output Power Class AB Amplifier Applications in HF Band

Absolute Maximum Ratings: (T_C = +25°C unless otherwise specified)

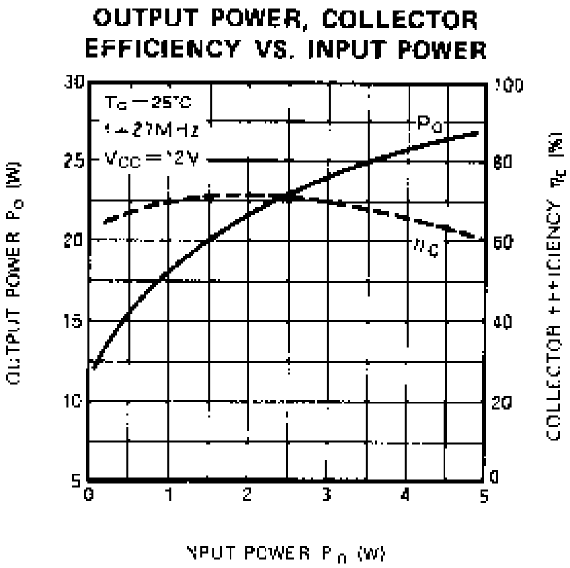
Collector-Emitter Voltage (R_{BE} = Infinity), V_{CEO}	25V
Collector-Base Voltage, V_{CBO}	60V
Emitter-Base Voltage, V_{EBO}	5V
Collector Current, I_C	6A
Collector Power Dissipation (T_A = +25°C), P_D	1.7W
Collector Power Dissipation (T_C = +50°C), P_D	20W
Operating Junction Temperature, T_J	+150°C
Storage Temperature Range, T_{stg}	-55° to +150°C
Thermal Resistance, Junction-to-Case, R_{thJC}	6.25°C/W
Thermal Resistance, Junction-to-Ambient, R_{thJA}	73.5°C/W

Electrical Characteristics: (T_C = +25°C unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C = 1mA, I_E = 0	60	-	-	V
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C = 10mA, R_{BE} = Infinity	25	-	-	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E = 5mA, I_C = 0	5	-	-	V
Collector Cutoff Current	I_{CBO}	V_{CB} = 30V I_E = 0	-	-	100	µA
Emitter Cutoff Current	I_{EBO}	V_{EB} = 4V, I_C = 0	-	-	100	µA
DC Forward Current Gain	h_{FE}	V_{CE} = 12V, I_C = 10mA, Note 1	10	50	180	
Power Output	P_O	V_{CC} = 12V, P_{in} = 1W, f = 27MHz	16	18	-	W

Collector Efficiency			60	70	-	%

Note 1. Pulse test: Pulse Width = 150µs, Duty Cycle = 5%.



ERF-2030 Features...

1/ The ERF-2030 is a 25 watt* transistor - therefore, it is not just a replacement part, but also an UPGRADE to the old Mitsubishi part.

2/ The ERF-2030 is NOT an "electrical drop in replacement" for the 2SC2166, 2SC1969 and 2SC2312. However, circuit modifications on most radio's are minimal and documentation is readily available for FREE.

3/The ERF-2030 is a "mechanical drop in replacement" for the 2SC2166, 2SC1969 and 2SC2312. This means that the The ERF-2030 features a TO-220 package with the SAME pinout configuration as the 2SC2166, 2SC1969 and 2SC2312. Therefore NO mechanical modifications to the ERF-2030 are necessary for most installations

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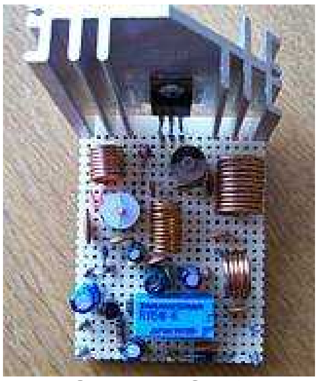
Allmode RF Power Amplifier for the 15 meterband (21Mc)
RE-PA10HF15



By Guy, de ON6MU

About the 15-meter band HF amplifier RE-PA10HF15

All is already explained above (17-meter band amplifier): Read it here

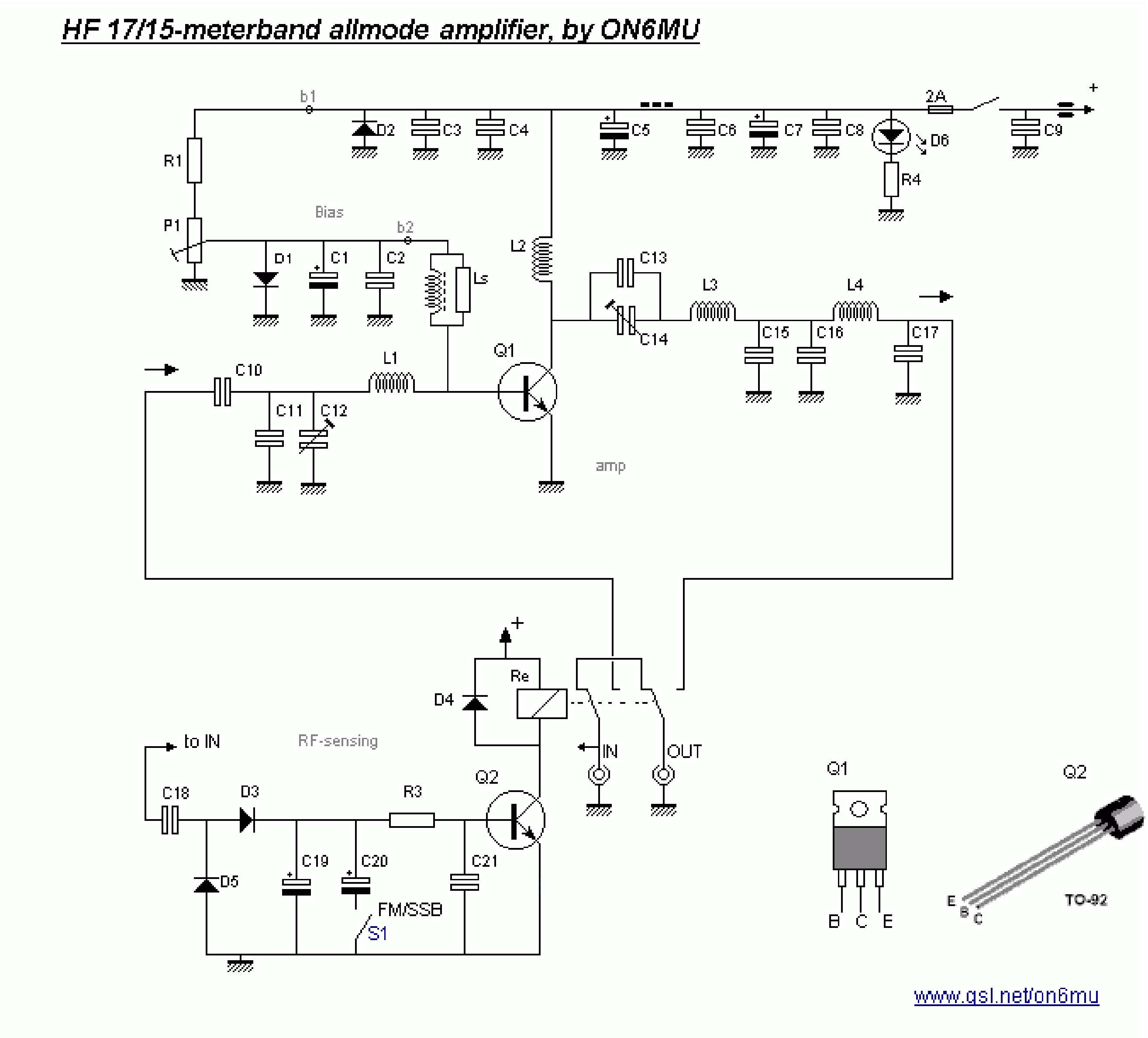
15-meterband Amplifier settings

First set C12 and C14 to the middle and centre pin of P1 to the ground. After carefully mounting all parts and using as short as possible connections between the parts, gently add voltage to the amplifier while checking the current. The only current you should see is a the liddle idle current of Q1 (and LED D6 if connected). Increase the voltage to 12 volts. Check current again. It should (at this stage) be lower then +/- 20mA.

Now gently turn P1 till you get approx. 35 mA. Do not forget to mount Q1 on a heat sink isolated but electrically from the transistor.

So far so good? Now we check if the RF-sensing circuit is working properly. Connect a proper dummy load and a power meter to the output of the amp. Remove any connectors from your power supply and temporary disconnect the collector from the VCC. Connect your transceiver to the input. Be sure you set your tranceiver's power to minimum (never more then 3 watts) and you set your transceiver to 21.200Mc in CW/FM. Key your transceiver and if all goes well the Relay should power up and you should see the current rise and your power meter should already show an amplification of the RF input power.

Still all working as planned? Excellent! Now carefully turn C12 till you get maximum output power (whilest checking the input SWR on your transceiver or SWR meter). And finally tune C14 to maximum power. If needed re-tune C12 and C14 till you reached the maximum. Current should be around 1.2 Amp +/- (depending on the voltage and input power).

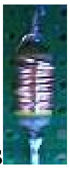


Parts list 15-meterband power amplifier RE-PA10HF15

- Q1 2SC1969 (only Mitsubishi type!!), 2SC1173, 2SC1944 (with proper heatsink isolated from the transistor)
- Q2 BC338, 2N2222
- C1 1uF/25v
- C2 22nF
- C3 10nF
- C4 560pF
- C5 22uF/25v
- C6 47nF

- C7 100uF/25v
- C8 1nF
- C9 100nF
- C10 68pF
- C11 100pF *(If amp oscillates in higher frequencies do to transistor deviations or PCB coupling, try 180pF)*
- C12 6...40pF set at half position and tune to max power and best input SWR
- C13 56pF
- C14 6...40pF set at half position and tune to max power on 50 Ohm dummyload
- C15 100pF
- C16 47pF
- C17 150pF
- C18 8pF
- C19 2.2uF/25v
- C20 68uF/25v
- C21 100nF
- R1 1k5 (revision 1.2)
- R3 1k5
- R4 1k
- P1 5k (revision 1.2) pot. to set BIAS for correct SSB operation +/- 35mA@13.8v
- D1 1N4148 (revision 1.2)
- D2 1A si diode 1N4001, 1N4005
- D3,D4,D5 1N4148
- D6 LED
- Re = 12volt relay with silver plated contacts and low RF capacitance with 2times 3pole switch: RY12W-K
- L1 = 1mm CuI (insulated copper wire), 6.5 turns close together, 7mm inside diameter
- L2 = 0.6mm CuI (insulated copper wire), 12 turns 0.5mm space, 7mm inside diameter
- L3 = 1mm CuI (insulated copper wire), 11 turns close together, 10mm inside diameter
- L4 = 1mm CuI (insulated copper wire), 4.5 turns close together, 10mm inside diameter
- Ls = 470 1/2 watt carbon, 0,2 CuI turned 3 times over the entire length of the resistor

- Ferrite bead 3 turns wire inside
- S1 switch open = AM/CW/FM/PSK/PKT, switch closed = SSB

Ls 

Note:
Always use a dummy load for testing and adjusting the amplifier!!!

Specifications

- Peak Frequency range: 21Mc...21.5Mc
- Output RF power: at least 8W @ 13.8v - 12W@16v
- All modulation modes
- Adjustable output impedance to 50 Ohms
- Adjustable input impedance to 50 Ohms
- High efficient band-pass type harmonic L-filter + lowpass PII filter
- PII-filter at input
- Usable voltages: Vcc 10 - 18 volts
- Average current I: +/- 1A @ 14 v
- RF-sensing
- VSWR overload resistant (not infinite)
- Can be used without complex BIAS if only needed for CW/AM/FM/FSK type modulation

Antenna's

It's important to use a correct designed antenna according to band you would like to operate, or at least use a good antenna tuner to match the antenna (protecting your transmitter and proventing harmonics/interference...). Several examples can be found on my website and all across the Web. A dipole is always a good alternative (total length = 150/freq - 5%).
The performance (distance relative to you RF power) of your antenna is as importent (if not more) as the RF power you transmit! A dummy load gives also a perfect 1:1 SWR, but you wont get any farther then the street you live in HI. Finally, athmospheric conditions (D-,E-,F-layers depending on the frequency you're using) is equally important to be able to make DX QSO's.

Related

Remember that transmitting and/or using an power levels higher then your local license permit is illegal without a valid radioamateur license!

Another related project:1watt 10 meterband transmitter project

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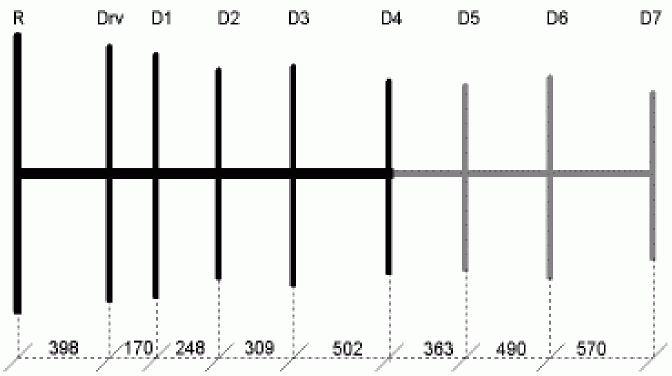
Optimized 6/9-ELEMENT VHF YAGI

de ON6MU

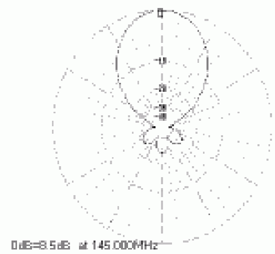
Fig.1: Top view



Element	Length	Prog. Spacing
Reflector	1014	0
Driver	980	398
Director 1	946	568
Director 2	882	816
Director 3	904	1125
Director 4	876	1627
(Director 5	870	1990)
(Director 6	900	2480)
(Director 7	830	3050)

Boom +- 20 x 20 mm.
Aluminum tubing for all elements and 10mm. thickness except for the reflector that's 12mm. thickness.

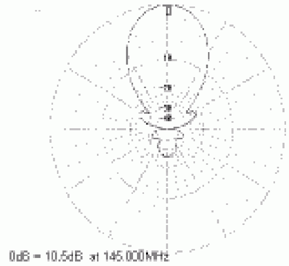
Fig.5: Antenna pattern 6-element



Specifications 6-element

Forward Gain	=	8.5 dBd
Front-to-Rear ratio	=	26 dB
SWR on 145 MHz	=	1
SWR on 144 & 146 MHz	=	1.2
Ver.-plane pattern	=	53°
Hor.-plane pattern	=	42°
Max. bandwidth	=	4MHz

Fig.6: Antenna pattern 9-element



Specifications 9-element

Forward Gain	=	10.5dBd
Front-to-Rear ratio	=	26 dB
SWR on 145 MHz	=	1
SWR on 144 & 146 MHz	=	1.2
Ver.-plane pattern	=	40°
Hor.-plane pattern	=	34°
Max. bandwidth	=	4MHz

Fig.2: Example of an aluminum bracket to mount SO-239 or N on boom

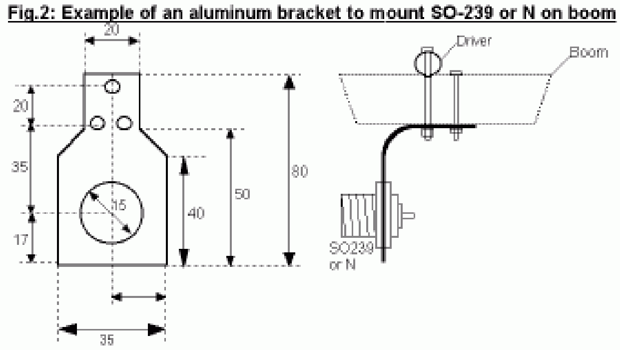


Fig.3: GAMMA MATCH with concentric tubing

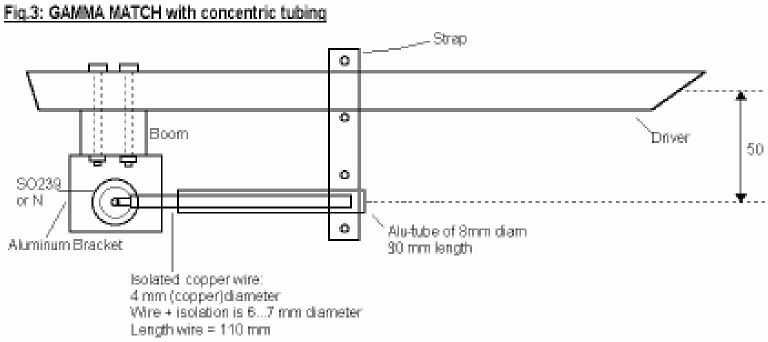
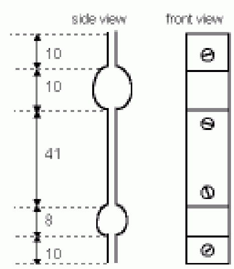


Fig.4: Aluminum Strap



Notes:
All elements are connected to the boom directly (NOT isolated from the boom). You may mount them on top of the boom or through the boom.
Regulate the Gamma-match until best SWR is found on the desired center frequency by sliding the strap and/or Alu-tube.
Use some grease between all connections and seal everything up with silicone to prevent corrosion.

73" Guy, ON6MU

Note: the antenna can also be tuned between 142...148MHz

Interesting antennas and stuff:

Pictures and details of the optimized VHF Yagi antenna

Greg SP5LGN, and how he made it:





click to enlarge the images

How Luc ON5DL made it:



he made this antenna in two hours!

click to enlarge the images

How Geert ON3GVG made it:



Thanks Geert!

Charles KC8VWM and how he made my optimized VHF Yagi Antenna RE-A144Y6/9:

ON6MU 9el Yagi Antenna Design

The computer optimized 9 el. homebrew antenna is performing very well. I have made many long distance contacts using the ON6MU VHF Yagi antenna. I have the antenna located only 35 feet above the ground. (See antenna photo titled KC8VWM to see how high it is mounted on my house.)

The very first day I put up the ON6MU antenna, I contacted two stations in Toronto Canada which is located 507 km. away from me. Other stations I contacted were located in other states like Buffalo, New York, Pennsylvania, Indiana, Tennessee, Michigan, and West Virginia.

I was also picking up weak EME signals later that evening on 144.127 MHz. using mode JT65B.

Back to front and measurements:

Checking Element Alignment

Element Mounting Method

Gamma Match Closeup

Gamma match mounting

Converted from a radio shack VHF Yagi antenna:

Right side view: notes on the element layout/design and why:

Left side view: tuned and ready to install

KC8VWM QTH: the ON6MU VHF optimized antenna mounted on top of the roof

The original TV antenna model (Radio Shack VU 120 XR) I used for the entire construction of the ON6MU antenna design can be found here:

http://www.hdtvprimer.com/ANTENNAS/VU-120XR.html

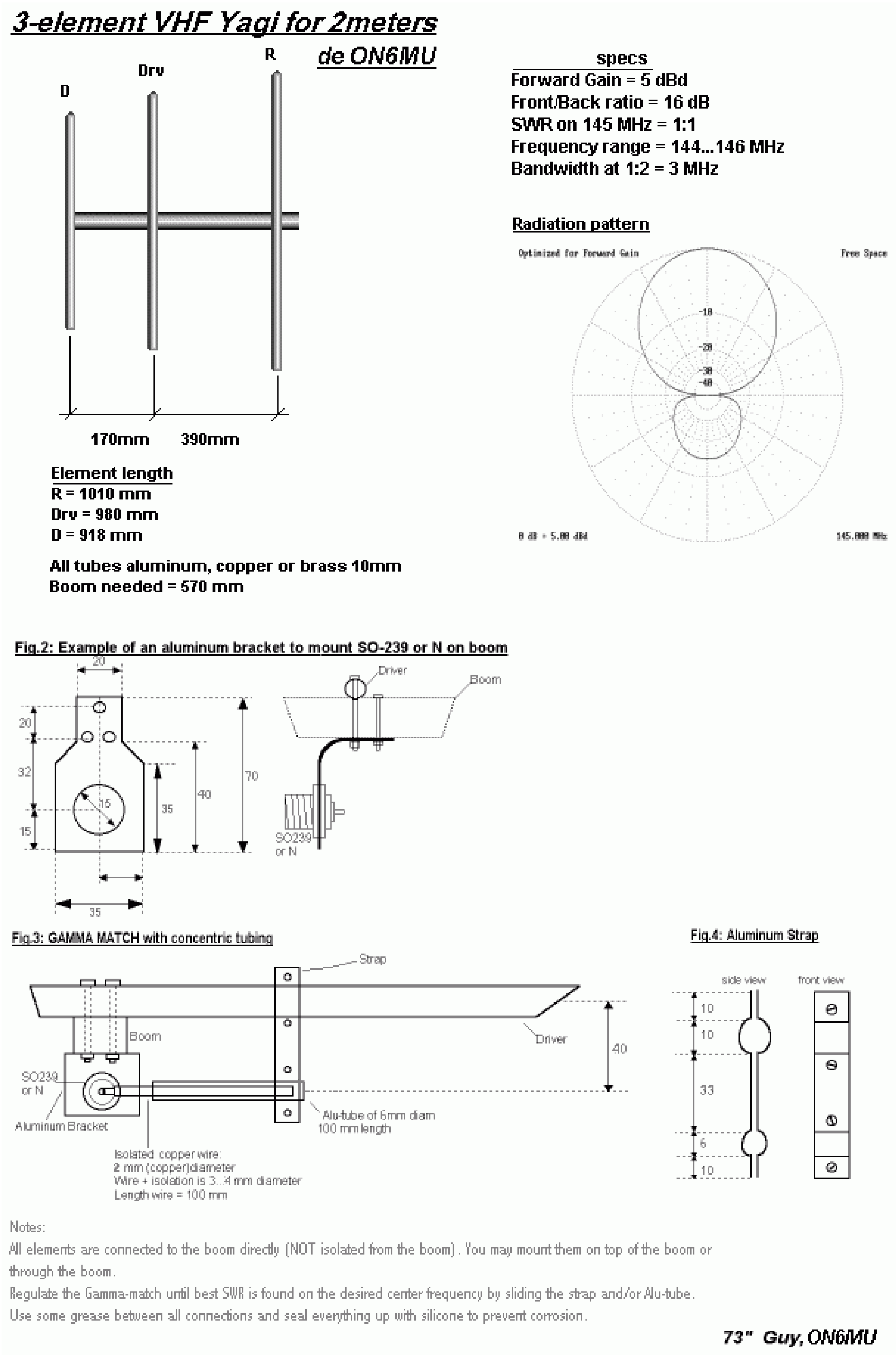
73

Charles KC8VWM
Thank you for the feedback and photo's Charles!

My Yagi 9-element version
made by ON2BJS

Thanks Bechir

3-element VHF homemade (portable) yagi RE-A144Y3



Note: the antenna can also be tuned between 142...148MHz

Details


Pictures on how SWL Voiculescu Eduard made it.
click to enlarge
Thanks Eduard!

These are some examples of PA0CDR



click to enlarge
Thanks Gerlof

More projects:

ON6MU
HOME

A POOR MAN’s ANTENNA ANALYSER

(With sincere thanks to that outstanding engineer/designer, Jim Tregellas VK5JST [1], whose original work inspired me, for his patience, advice, understanding, tolerance and good humour in answering my many e-mails instead of telling me where to go!)

PART 1

With being a “canny Scot” (not to mention an O.A.P radio amateur), perhaps comes a certain increased motivation to look for cheaper, which in turn generally means simpler, solutions to problems which continue to confront me in this life-long, yet still stimulating hobby of ours.

The completed “Mk4” antenna analyser

I am in no doubt that in my early radio amateur days, and as a result of the lack of proper measuring equipment, mostly limited to a home-brew multimeter and a G.D.O. (grid-dip oscillator – blame Lee de Forrest for the “grid”!), I must have spent – sorry, *wasted* - hundreds of hours and miles of copper wire, in numerous early attempts at making the perfect antenna and any associated loading coils or traps. The G.D.O usually gave me more dips than the “big dipper” and I mostly had little idea what they *really* indicated.

Many moons later, along came the now almost ubiquitous “antenna analyser”, in particular the MFJ-259. It seemed too good to be true – a possible solution to most of my problems…except one, I couldn’t really justify spending £200 or more on one little black box. Luck was at hand however, on a visit to my old pal Bob Hope (the late LA2UA/5Z4LW) in Stavanger. Bob had won an MFJ-259 in a raffle, could see no need for it and would I like it (for past services rendered!)? I didn’t have to be asked twice.

My world changed. Suddenly, guessing went out of the window, and I could accurately measure a host of previously semi-mysterious variables, and design and analyse the performance of antennas, especially portable and/or mobile. I was truly hooked and some years later, when the opportunity arose to buy the later “259-B” version for £100 new in the U.S.A. arose, how could I resist?!

But, and despite the virtues of these analysers, they remain beyond the pocket of many. I asked myself many times why this was so. Maybe the “canny Scot” in me makes me more curious/inquisitive. What makes them “tick”? Well, a typical analyser consists of an oscillator feeding a Wheatstone-type bridge, a frequency-counter and of course the aerial. The oscillator needs to be sinusoidal, wide-band, constant amplitude, stable and be able to deliver some power to the aerial under test – a tough specification! Various bridge voltages are interpreted to produce readings of aerial input impedance and S.W.R.

Despite the tough spec’. I asked myself if such an instrument could be home-brewed at much less cost. Having, in my teaching days, successfully built many simple frequency counters, that didn’t seem a problem. The oscillator was a different story. Like many RAOTA members, my first transmitter was home-brewed. At the time (in the 60s), I built every conceivable valve oscillator (Colpitts, Hartly, Clapp, Pierce, Franklin, Tesla etc.etc) in the search for the elusive one which could be dropped from a foot above the bench, which had zero thermal drift, was unaffected by loading and produced a pure tone…I believe I got as close as was humanly possible on a near-zero budget and with limited East-African resources!

Fortunately, I now have a reasonably well-stocked junk-box. The first step was to design an ultra-simple but accurate 4-digit frequency counter around the now almost obsolete 74C925 counter chip I had saved from my long-gone days as a physics/basic electronics teacher. This worked to perfection. Then the problems began – the *oscillator*. This had to be stable, both in terms of frequency and amplitude, as well as sinusoidal (i.e. harmonic free), ideally from below 1.8MHz to at least 30MHz, as well as being capable of supplying some power to a low-impedance load. My '60s solutions were useless….
At about that time, I had an e-mail from Patrick GW1SXN mentioning that Jim VK5JST had designed an MFJ 259B-type antenna analyser around a very stable, constant amplitude, wide-band "power" oscillator and a multi-function LCD display, the whole lot being controlled by a P.I.C. chip. It was (and still is, I believe) available to Australian amateurs (and indeed anyone anywhere) in kit-form and at the then incredibly low price of *less than £40*! In true amateur fashion, Jim had also made the circuit and an excellent description, freely available on the internet (2).
Despite an intrinsic fear of P.I.C. chips (based wholly on my ignorance thereof), the Scot in me surfaced again, with the reasoning that if an Aussie could do it for £40, maybe (by cutting a few corners!), a Scot could do it for under £20! The target was set. Right away, I decided to omit the PIC chip…my analyser would not be able to compute reactance or impedance. However, I was more concerned with SWR and impedance at *resonance*.

The oscillator problem would be solved by (reluctantly) "copying" that part of Jim's circuit. After much staring at the circuit and head scratching, I finally felt I understood roughly how it worked. More problems arose…Jim used a double sided P.C.B (one side acting as a ground-plane) and transistors which I could not find here in the U.K. After much pouring through transistor data, I plumped for what I considered to be a near-equivalent, readily available and costing a few pence each. I could have ordered the P.C.B. from Jim, but this was "cheating" going a bit far! I opted (to Jim's total amazement and, more especially, horror) for my much-practised, miniaturised Veroboard techniques. After many months of utter frustration (spread over two winters), but driven on by stubbornness and a determination to make it work against all the odds, I finally succeeded…not quite perfectly…I had to add an output FET buffer stage…Jim later reckoned my chosen transistors, despite seeming to be near-identical, were in fact "marginal"…I would now agree!!
I now had the necessary low output-impedance power oscillator with which to feed a fairly traditional Wheatstone bridge circuit. A few diodes and some op-amps completed the set-up. All that was left to do was to produce a new meter scale, to show aerial resistance (at resonance) and S.W.R. A quick check of my miscellaneous aerials showed that my analyser was in indeed not only capable of producing the same basic results as the MFJ-259, but at a fraction of the cost. I had in fact reached my target of "less than £20". Admittedly, I did have most of the components in my junk box, but I believe the target figure would have been achieved (or very close to it) had I had to buy all or most of the components.

Sad to say, having reached my goal, the instrument (as with many other completed "challenges)" now adorns a shelf in the shack. But, in a way, that's not the end of the story…rather the beginning of another.

PART 2

Forever seeking a challenge, I asked myself just what minimum "feed-back" the average amateur *really* needs, to ensure his/her aerial, commercial or home-brew, will work with the maximum efficiency theoretically possible for that particular design. I am also constantly aware that aerials are the one field in our hobby where it is still possible to experiment and meet the "raison d'etre" of our licence [as stated in the introduction thereto – Para.1, sub para. 1(1)(a)], and ultimately where considerable savings can indeed be made.

First of all, I observed that the majority of us work with *resonant* aerials. This means that the input impedance of the aerial, whilst perhaps not the ideal 50 ohms, *is* purely *resistive*, i.e. the reactance X is zero, hence the input impedance Z is simply R. Secondly, none of us needs a sophisticated oscillator of the type described earlier – we already have an even better one…in our rigs. Indeed, what are rigs but high quality, stable, wide-band, relatively powerful oscillators?! Furthermore, and for the same reason, we do not need a frequency counter. We *do* need an SWR-meter as this, together with a knowledge of R, will allow us to properly *match* the "R" of our aerial to the output impedance of our coax and our rigs (generally 50Ω). The remainder of this article describes a simple instrument which achieves all this, and perhaps best of all requires ***no power source*** other than a few watts of RF power from the TX!

Let us first of all look at how a typical "antenna analyser" works? The answer in some ways is "quite simply"…

Referring to **Fig.1**, the TX (suitably attenuated) produces an r.m.s. voltage **V** (typically 10V) across one diagonal of a conventional Wheatstone bridge (re-drawn in "rectangular" form for ease of interpretation) with 50Ω resistors in three of its arms, the unknown resistor $\mathbf{R_x}$ (the aerial) being placed in the remaining arm. This results in voltages $\mathbf{V_A}$ and $\mathbf{V_B}$ appearing at opposite ends of the other diagonal. As $\mathbf{R_1 = R_2 = R_3 = 50\Omega}$, $\mathbf{V_A}$ is **V/2**. $\mathbf{V_B}$ will depend on the relative values of $\mathbf{R_3}$ and the unknown load $\mathbf{R_x}$. $\mathbf{V_A}$ and $\mathbf{V_B}$ are then rectified by $\mathbf{D_1}$ and $\mathbf{D_2}$ respectively, producing d.c. voltages **√2** times the r.m.s. values. Diode $\mathbf{D_3}$ produces a third d.c. voltage representing the *difference* between $\mathbf{V_A}$ and $\mathbf{V_B}$. If we represent these three d.c. voltages by $\mathbf{v_1}$, $\mathbf{v_2}$ and $\mathbf{v_3}$ (and, for the time being, neglect diode forward voltage drops), we have:

$\mathbf{v_1 = \sqrt{2}V_A}$ $\quad$ $\mathbf{v_2 = \sqrt{2}V_B}$ $\quad$ and $\quad$ $\mathbf{v_3 = \sqrt{2}(V_B - V_A)}$

Let us now consider the following three basic bridge conditions:

(i) $\mathbf{R_x = 0}$ (ii) $\mathbf{R_x}$ **= 50 ohms** (iii) $\mathbf{R_x} = \infty$

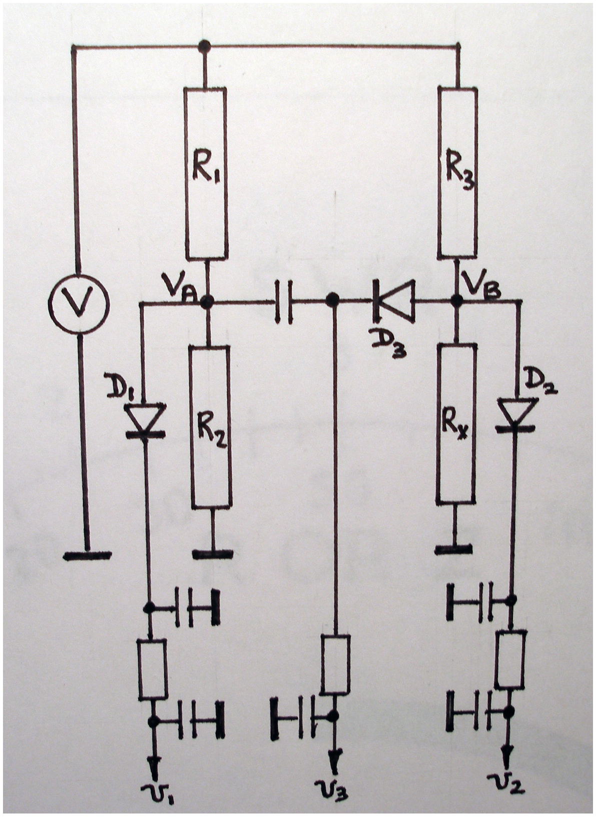


Fig.1

[Note: Errors caused by the diode forward voltage drops are minimised by using *Schottky* barrier types ($V_f \approx 200mV$ or less). A sensitive meter (50µA or 100µA) is also used. The other resistors and capacitors simply provide RF filtering].

$\mathbf{R_x}$	$\mathbf{V_A}$	$\mathbf{V_B}$	$\mathbf{v_1}$ (= √2 $\mathbf{V_A}$)	$\mathbf{v_2}$ (= √2$\mathbf{V_B}$)	(the magnitude of…) $\mathbf{v_3 = v_2 - v_1}$
0	**V/2**	**0**	**0.707V**	**0V**	**± 0.707V**
50	**V/2**	**V/2**	**0.707V**	**0.707V**	**0**
∞	**V/2**	**V**	**0.707V**	**1.414V**	**± 0.707V**

Table 1

Studying this table, we see that as it does not change with changing load, $\mathbf{v_1}$ **can therefore be used to *represent* applied input power or voltage**. We also see that the value of $\mathbf{v_2}$ depends on the value of $\mathbf{R_x}$, ranging from **0V** when $\mathbf{R_x = 0}$ to **√2V** when $\mathbf{R_x} = \infty$. Voltage $\mathbf{v_2}$ **can therefore be used to represent** $\mathbf{R_x}$**.** Finally, voltage $\mathbf{v_3}$ is **0V** when $\mathbf{R_x = 50\Omega}$ (SWR = 1) rising to a maximum of **0.707V** when $\mathbf{R_x}$ tends either to zero or to infinity (SWR = ∞ in both cases). $\mathbf{v_3}$ **can thus be used to indicate SWR** on a scale calibrated from 1 to infinity (∞).
It should be noted that the $\mathbf{R_x}$ scale will be incorrect for reactive loads. However, $\mathbf{v_2}$ is always a *minimum* at resonance - a useful indicator thereof. The **SWR** and $\mathbf{R_x}$ scales are clearly *non-linear* but can be established using a selection of known resistors, or by calculation (see later).
Jim VK5JST demonstrates mathematically that, irrespective of whether $\mathbf{R_x}$ is purely resistive or complex (i.e. **R + jX**), the resulting SWR scale ***is*** in fact correct.

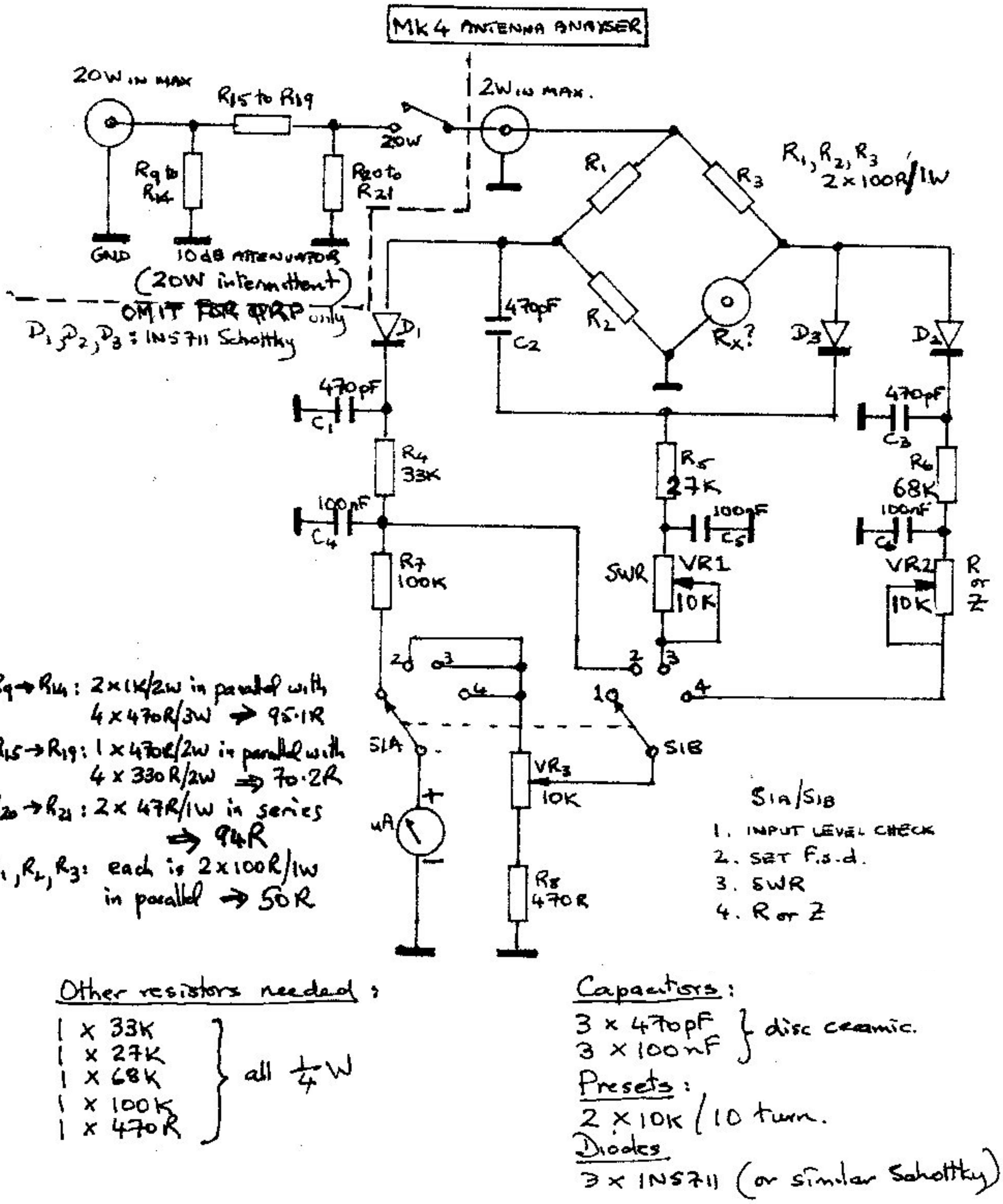


Fig.2 (including minor component value changes as of May 2013)

In the circuit diagram (**Fig 2**) above, resistors R9 to R20 form a Π-pad 10dB attenuator (**2**). Two inputs to the bridge are available. When the "HIGH" input (20W max.) is selected (TX connected to "HIGH I/P" and switch closed), the signal passes to the bridge via the 10dB attenuator which reduces the power by a factor of 10. When the "LOW" input is used (2W max.), the signal is fed directly to the bridge. After completing assembly, the analyser is pre-calibrated, WITH NO AERIAL CONNECTED, as follows:

(i) switch S1 to "I/P LEVEL" (position 1), apply 1→2W directly to the bridge (or about 10→20W via the attenuator) and check that the meter reading is in the "INPUT OK" (green) range.
(ii) switch S1 to "F.S.D." (position 2) and adjust VR_3 for full-scale deflection (∞ on SWR scale)
(iii) switch S1 to "SWR" (position 3) and adjust VR_1 to give full-scale deflection (∞ on SWR scale)
(iv) switch S1 to "R or Z" (position 4) and adjust VR_2 to give full-scale deflection (∞ on "R or Z" scale)
(v) If a good 50Ω dummy load is available, check that S.W.R. is 1 : 1 and R_x is 50Ω! (N.B. Always set F.S.D. before taking SWR and R_x readings on any aerial).

CONSTRUCTION:

Over many years managing 'O' Level Electronics projects in schools, I developed (as mentioned earlier) my own "Veroboard" assembly method which has worked well for both simple and more complex projects. The layout of the main board is shown in **Fig.3** below:

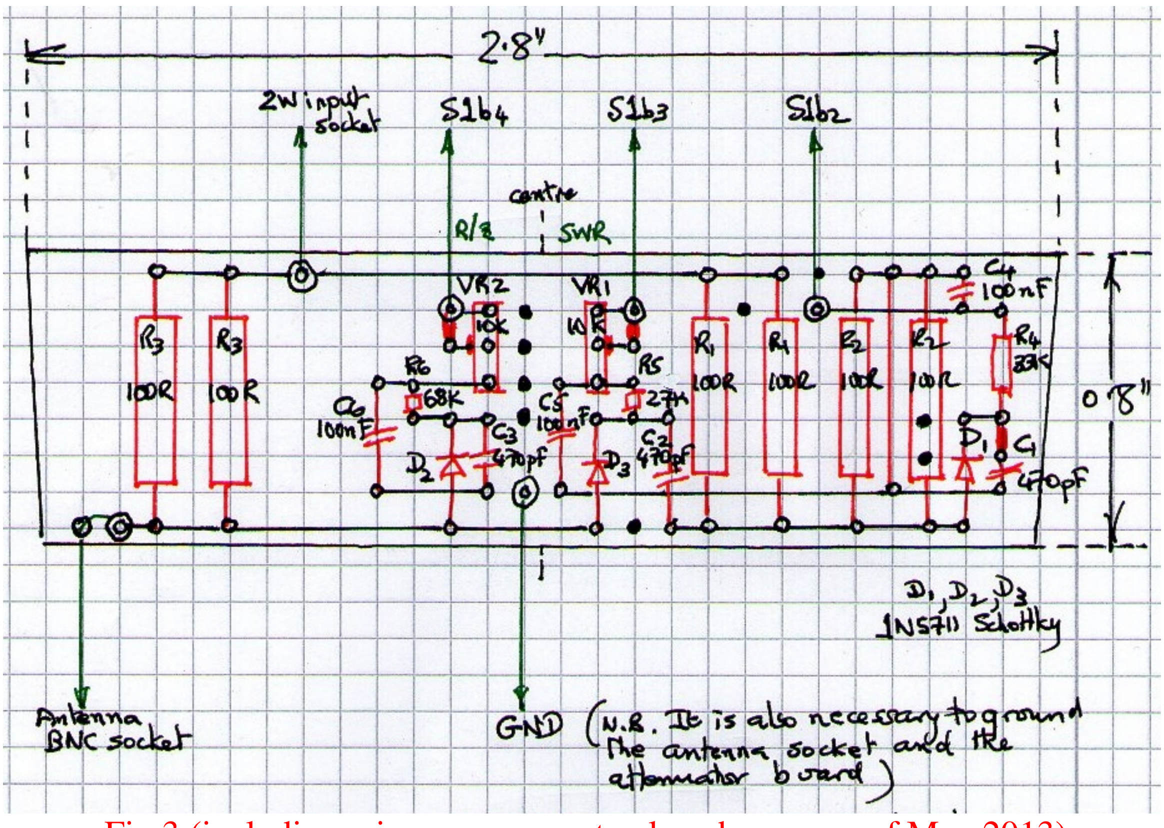


Fig.3 (including minor component value changes as of May 2013)

VR_1 and VR_2 are shown "dotted" as their exact position will depend on their shape, physical size and pin layout. The edges of the board are tapered, as the 4" x 3" x 1.5" ABS plastic boxes used are themselves tapered. The 2.9" (tapering to 2.8") x 0.8" board slots into the "guides" at each side of the box.

A slight variation of the technique, using double-sided PCB was used for the construction of the 10dB attenuator (**Fig.4**).

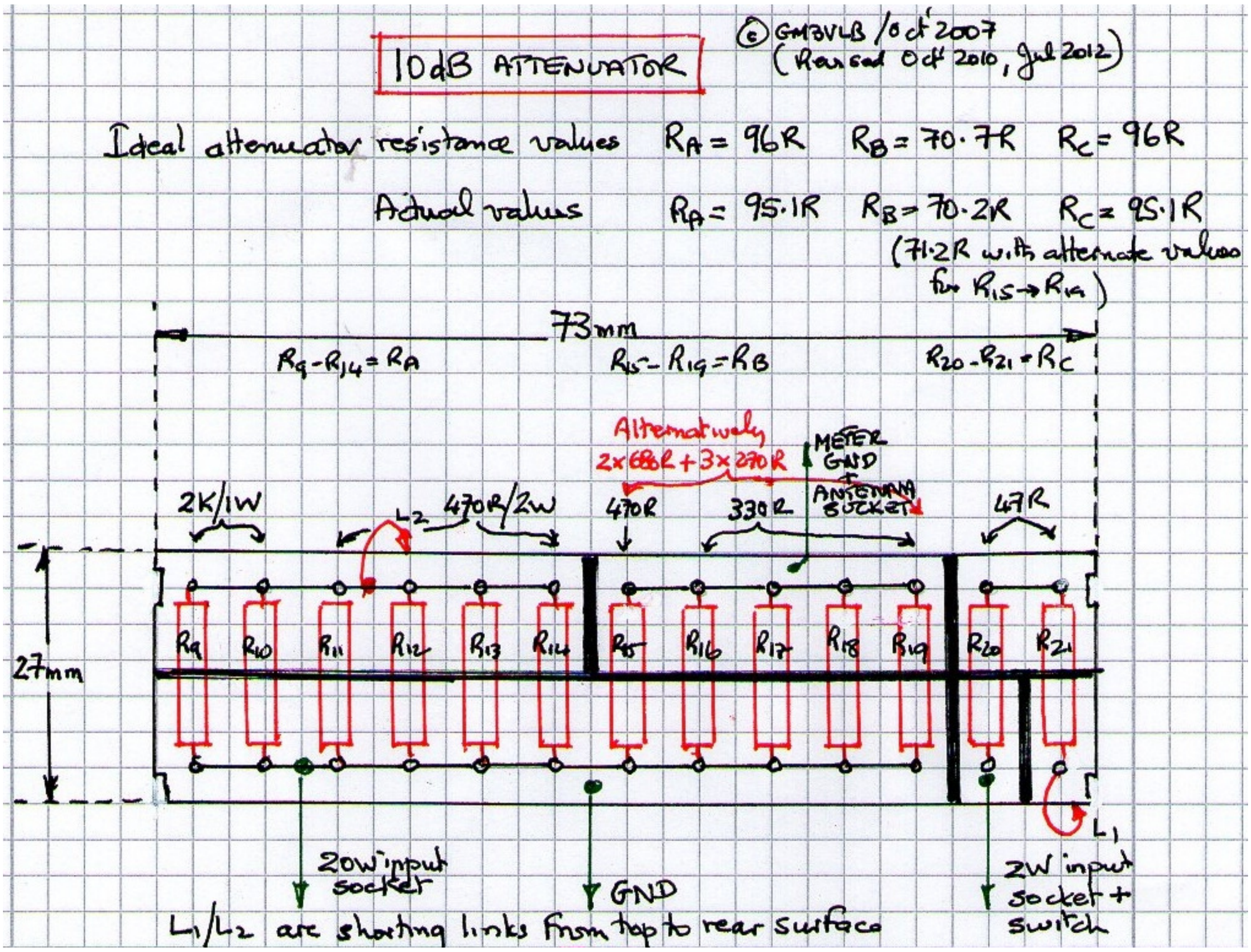


Fig.4 (including minor component value changes as of May 2013)

Creating an *SWR* scale from readings of v_3

Clearly, the scale will depend on the meter used (I was fortunate to acquire some new high quality, very linear and very good value, Russian military 50µA meters from Bulgaria on eBay!).
Whilst both scales can be created using a selection of known (non-inductive) resistors, I preferred to use some simple maths and do some (repetitive) calculations. For these, I assumed an input power $\mathbf{P_{IN} = 2W}$ and $\mathbf{R_{IN} = 50\Omega}$, so that $\mathbf{V_{bridge} = 10V}$ (r.m.s.). (from $\mathbf{P = V^2/R}$). So as not to overwhelm everyone with off-putting mathematics, I will only reproduce the final formulae from which you could produce your own scales (I am happy to e-mail or post the missing "details" to anyone requesting them)

For meters with *linear* movements (not "VU" meters for example), where the meter angular deflection $\boldsymbol{\theta}$ is proportional to $\mathbf{v}$, and $\mathbf{v_x}$ is the "unknown" voltage, it can be shown that

$$\mathbf{v_x/v_{fsd} = (SWR - 1)/(SWR + 1)}$$

and $\quad \boldsymbol{\theta_x/\theta_{fsd} = v_x/ v_{fsd}}$ or $\boldsymbol{\theta_x = \theta_{fsd}\ (v_x/ v_{fsd})}$ or $\boldsymbol{\theta_x = \theta_{fsd}(SWR - 1)/(SWR + 1)}$

$\boldsymbol{\theta_{fsd}}$ is of course the angle for full-scale deflection for the particular meter used (mine was 87°). A table of angles corresponding to chosen SWR values can thus be constructed, and a new scale produced, for any chosen meter. I found Jim VK5JST's scale points very convenient and used these. The scale is *numbered* at SWR 1, 1.5, 2, 3, 5, 10 and ∞, with 4 intermediate graduation marks between SWRs 1 and 1.5, 1.5 and 2 and 2 and 3, as well as single marks at 4, 6, 7, 8 and 9.

N.B.: In the case of SWR, the *forward voltage drop* V_f of the diode is *not* a variable, and, as stated previously, the scale is also correct for *reactive* loads.

<u>Creating a *resistance* scale from readings of v_2</u>

In this instance, diode forward voltage drop IS a variable. In the relevant calculations, I have assumed a typical Schottky value of 0.2V. As a consequence, $\mathbf{R_x} = \mathbf{0\Omega}$ occurs a shade *below* actual zero volts, whilst $\mathbf{R_x = \infty}$ occurs a shade *above* actual f.s.d. As a further consequence, the $\mathbf{R_x}$ scale is in fact only correct for one specific level of input power which in this design is $\mathbf{P_{IN} = 2W}$ (or **20W** via the attenuator). The scale IS correct at ½ f.s.d., i.e. $\mathbf{R_x = 50\Omega}$. However, at other power levels, the error is so small as to be insignificant. For example, if $\mathbf{P_{IN}}$ were only **0.2W** (i.e. an unlikely *10 times* less), there would be a progressively increasing error above and below 50Ω. For example, for a *real* $\mathbf{R_x}$ of 15Ω, the needle will be just over 1.5° too low, representing an *apparent* $\mathbf{R_x}$ of 13.5Ω – hardly discernible, and quite insignificant in the matching process.
Similarly, for a *real* $\mathbf{R_x}$ of 200Ω, the needle will be just under 2° too high, representing an *apparent* $\mathbf{R_x}$ of 228Ω, again hardly discernible and fairly insignificant. A power $\mathbf{P_{IN} = 2W}$ was chosen as the best compromise – this instrument was not designed as a *digital ohm-meter* – nor was it intended as an accurate scientific measuring instrument. It is a cheap, simple, hand-held, supply voltage-free, *informative* instrument, which allows the user to set up his/her aerial by indicating, fairly accurately, S.W.R. and input resistance at resonance. If necessary, simple transformer matching can then be used at the aerial input, thus dispensing with the lossy, inappropriate A.T.U. (another costly gadget). Now for some maths…

For an unknown resistance $\mathbf{R_x}$, $\mathbf{v_2}$ (see Fig.1) $\mathbf{= v_x = 14.14\,[R_x/(R_x + 50)] - 0.2}$

We need to *calculate* $\mathbf{v_x}$ for each value of $\mathbf{R_x}$ anticipated (I again used VK5JST's values of 10, 20, 30, 40, 50, 100, 200, 500 and ∞, with intermediate scale points – see photo')

If we *choose* "half f.s.d." to occur at $\mathbf{R_x = 50\Omega}$, $\mathbf{v_{fsd}}$ computes to be **13.74 volts.** Each scale point angle $\boldsymbol{\theta_x}$ can then be calculated by substituting the values for $\mathbf{v_x}$ (calculated above) in the following formula):

$$\boldsymbol{\theta_x = v_x\,(\theta_{fsd}/13.74)} \qquad (\theta_{fsd} \text{ is of course the meter f.s.d. angle})$$

FINALLY...High SWR presents NO risk of damage to the rig. If the aerial I/P is open-circuit, the impedance presented to the rig is **100Ω** (an SWR of 2 : 1). Similarly, if it is short-circuit, the impedance is **33.3Ω** (an SWR of 1.5 : 1). Both values are thus well within the safety limits of all transmitters.

I now keep this analyser in my own car for tuning my /M aerials (no risk then of losing/damaging my MFJ259B). The final Mk4 version uses the Russian 50μA meter and forms the basis of the present article. I have enough components to assemble a limited number of complete instruments at a cost of £70 (inc. P&P) – payable in advance. (I have been let down too many times!). For those wishing to "have a go", but feel that calibrating an existing meter is a bit too involved, I can supply a limited number of re-scaled 50μA meters (identical to mine) for £20 (inc. P&P).

Acknowledgements:

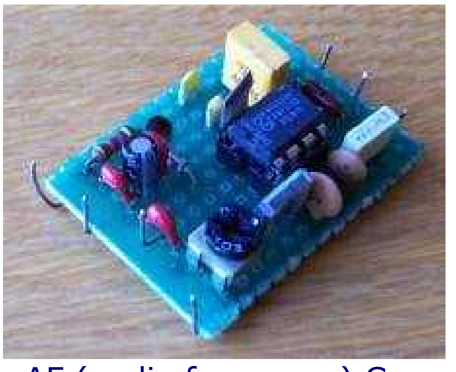
(1) Jim Tregellas, VK5JST (http://users.send.com.au)(e-mail: endsodds@internode.on.net), who planted the seeds, and in true radio amateur spirit, was free with his help and advice. (N.B. Jim's "Q-meter" design is also well worth looking at).

(2) 10dB Π Attenuator: p151, RSGB Radio Data Reference Book, by George Jessop G6JP

DRM
MF 455kHz -> AF Converter
RE-RXC0455/0012

(455kHz down converter)

MFC revision 1.4



MF (455kHz) to AF (audio frequency) Converter/Interface
to receive DRM singals your shortwave receiver, like the Yaesu FRG-100!
and FT-817/897

Please take also look at our Digital Analog Demodulation Project (DADP, VE7DXW)

Attention! The modification will be done at your own risk!

About the MF-LF converter/mixer RXC455/0012:

This is a very sensitive homemade MF converter/interface allowing you to receive the DRM radio (Digital Radio Mondiale) with your general coverage receiver and a soundcard. It can also be used for software radio apllications, and other MF to LF experiments (not just DRM, and surely not just for the Yaesu FRG-100)!
I've tested this project on a allmode Yaesu FRG-100 receiver. Within certain limits you can change the output bandwidth frequency to suit your needs. The converter is very stable, low noise, sensitive and low on power consumption.
The heart of the converter has been built around Philips SA602 (NE602, NE612, SA612), a twice balanced mixer oscillator. This IC finds his applications in layer capacity communication systems, cellular radio applications, RF data left, VHF-transceivers, broadband LAN's ed. IC in a ordinary 8-pin dual-in-line can be bought implementation (DIP) or 8-pin SO (surface-mount miniature package) implementation. Both implementation has a low cost. SA/NE602 a very low usage of only 2,4mA has! The total usage of the converter amounts to only 13mA. Therefore also uncomplicated usable applications fed with battery if needed, but in this converter's DRM application I use the voltage of the receiver itself.

The SA602A is a low-power VHF monolithic double-balanced mixer with input amplifier, on-board oscillator, and voltage regulator. It is intended for high performance, low power communication systems. The guaranteed parameters of the SA602A make this device particularly well suited for cellular radio applications. The mixer is a “Gilbert cell” multiplier configuration which typically provides 18dB of gain at 45MHz. The oscillator will operate to 200MHz. It can be configured as a

crystal oscillator, a tuned tank oscillator, or a buffer
for an external LO. For higher frequencies the LO input may be externally driven. The noise figure at 45MHz is typically less than 5dB. The gain, intercept performance, low-power and noise characteristics make the SA602A a superior choice for high-performance battery operated equipment. It is available in an 8-lead dual in-line plastic package and an 8-lead SO (surface-mount miniature package).

Revision 1.1(June 09)
I have added a low noise transistor (Q1) to amplify the output to a more convenient level, as I noticed that the audio level was just below the ideal level on one PC, whilest on my laptop the level was enough. Remember to set the ideal audio volume level if needed from within your OS. R4 (already existing in rev.v1.0) and C13 gives some additional filtering of the LF signal.

Revision 1.2(Nov 09)
I have noticed that by adding C17 hence limiting the highest frequency responce and amplifying the lower 5...20kC gave additional improvement.
P (trim pot) of 2k5 to allow exact LF output level setting for your soundcard input
Voltage for Q1 now also 6 volt (tapped from IC2)

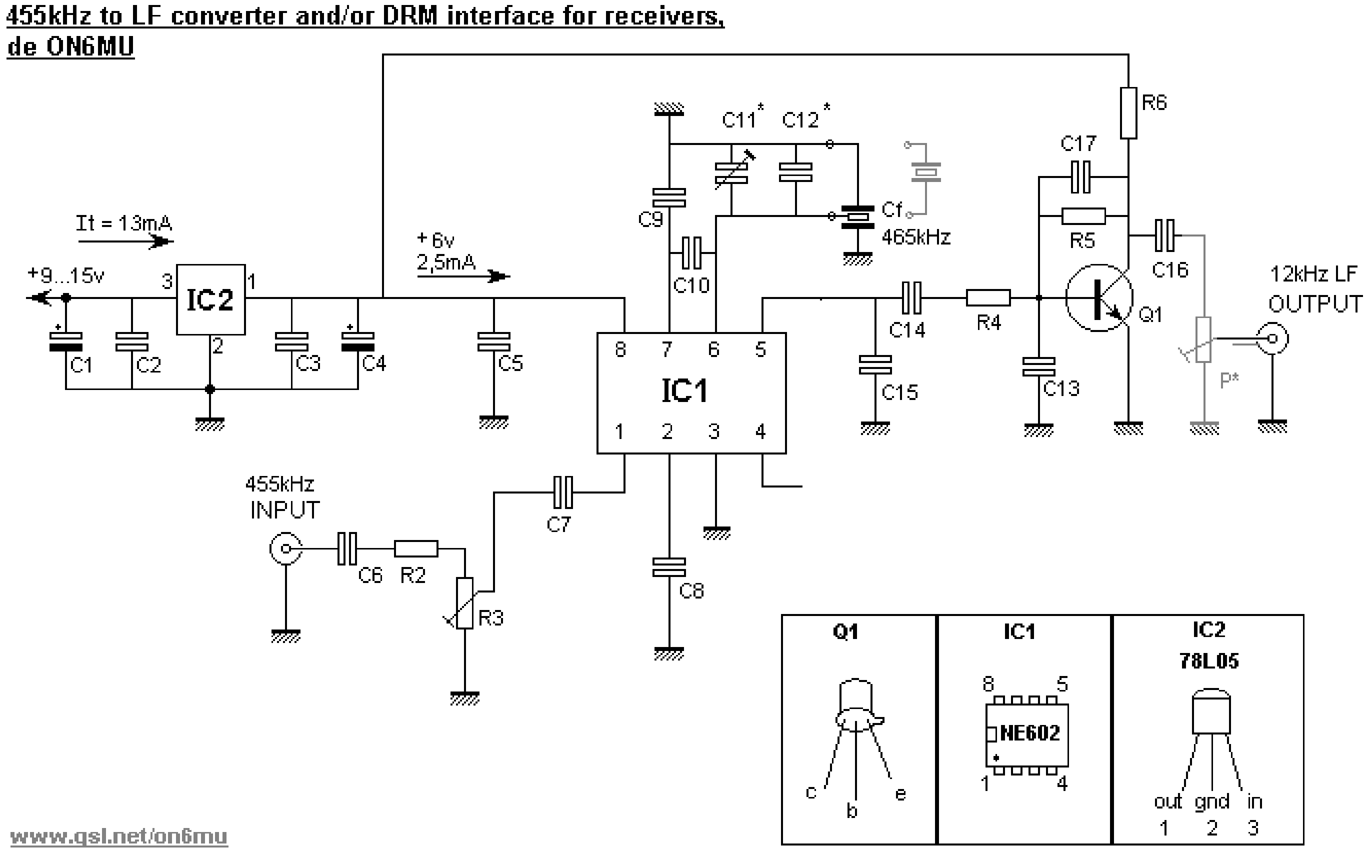
Revision 1.3b(Nov, 21th 09)
C19 & C18 added as it gave a noticable cleaner signal but lower LF output
R7 removed to compensate lower LF output
v1.3b: C18 added

Revision 1.4(Nov 14)
Changed the extractionpoint from the FRG
Some components left out to simplify the project further

RXC0455/0012 455KHz converter technical specifications

- Frequency range from 455kHz...467kHz
- LF/AF out 100...12kHz
- Power supply = 9...18v max
- Total power consumption = 13mA
- Power consumption IC1 = 2,5 mA
- Sensitivity = 0.22uV at 12dB SINAD
- Mixer noise figure = 4,6dB
- Input impedance = 3k
- Output impedance = 1k
- Local oscillator 467kHz
- Frequency stability = +/- 5Hz
- Operating ambient temperature range = -40 to +85°C

RXC0455/0012 SCHEMATIC



PARTS

IC1 = NE602/SA602 or NE612/SA612 (all pin compatible)
IC2 = 78L06
Q1 = BC109,BC107
C1, C4 = 2.2uF/25v
C2, C3 = 100nF
C5 = 470pF
C6 = 100nF(polyester)
C7 = 68nF (polyester)
C8 = 100nF
C9 = 1nF
C10 = 820pF
C11= 100pF trimmer
C12 = 220pF
C13 = 1n5 (poly) *v1.1*
C14 = 220nF (polyester)
C15 = 2n2 (mylar,poly)
C16 = 220nF (poly) *v1.1*
C17 = 120pF *v1.2*
Cf = 465B (ZTB465 kHz, or 470kHz) ceramic filter resonator
R1*= 10k (not specified in the schematic, see text)
R2 = 1k8
R3 = 10k
R4 = 1k
R5 = 100k (*v1.1*)
R6 = 2k2 *(v1.1)*
P* = 2k5 (*v1.2*)

Ceramic resonator:
Cf is a simple 465 khz ceramic filter (3 pin or 2 pin version can be used). These can sometimes be found in a AM/FM transistor radio, old wireless telephones etc.

Ideal would be a quartz version as this offers best stability and accurate resonating frequency of the mixer.
There are many out there that are not exactly on frequency! When using it for DRM the mixing frequency is not critical, so you can use a 470 kHz type too.
If the bandpass is not 12 kHz and the frequency is too high you will need to adjust the mixing frequency Cf by using C11.
If the bandpass does not reach 12kHz because of the mixing frequency being too low you will need to add a capacitor in series with the ceramic resonator Cf, something between 100pF and 300pF. I would recommend starting with 150pF (or use a trimmer).
- ceramic filters can be order here (only EU)

What's DRM

The Digital Radio Mondiale (DRM) purpose is to develop a non-proprietary technical standard for the replacement of analogue AM (Amplitude Modulation) radio with digital radio, also called DRM.

As a replacement for AM the existing channel spacing, medium and long wave 9 kHz and 10 kHz for short wave, is maintained. On medium wave a DRM radio broadcast can provide close to FM audio quality - most people will relate to the poor audio quality of AM music. With DRM the audio quality is primarily determined by the broadcast mode and spectrum occupancy (i.e. radio bandwidth of the DRM signal).

It also the displays the name of the radio station, program text, and automatic tuning to alternative frequencies will make DRM receivers easier to operate. DRM can also transmit multimedia html pages and data.

If you listen to a DRM signal on an ordinary short-wave AM radio then all you will hear is noise. There is no discernible modulation pattern when listening to DRM using a AM demodulator.
DRM Stations recent schedule list

The (DRM) converter explained using a Yaesu FRG-100

There are examples enough around which use another filter by replacing the original LF-H2S with a 12kHz or 15kHz wide filter. This allowed the user to use DRM reception by selecting the AM-narrow mode. The MF output is there tapped from the (hot) connection of VR1002 as seen from the front panel to the IF input of the converter(mixer).
In this modification I use the unused CW-filter connections hence avoiding to remove the top board and soldering/replacing the stock AMN filter. However, both methodes work.
Note: In this example DRM-mode is selected by selecting CW/N mode on your FRG-100.

Calibrating

The converter is best calibrated to fit 12 kHz wide LF output. C11 and C12 primary determines the offset of the base resonating frequency of the 465kHz filter. With a frequency counter you can check the resonating frequency which should be around 467kHz. The converter/mixer outputs 467-455=12kHz wide AF output to be fed to your PC's soundcard input.
Set C11 to get as close as possible to 467kHz. It is possible that C12 need to be changed to if the desired frequency isn't reached.
I have found that it isn't too critical, although calibrating gives the best result. However, it should work as is (set C11 to half way).
Set R3 to the best signal/noise ratio, hence also setting the maximum output of the converter.
Note:
You can add a trim pot of +/- 2k5 at the output of Q1 after C16 to set the ideal output for your soundcard input.

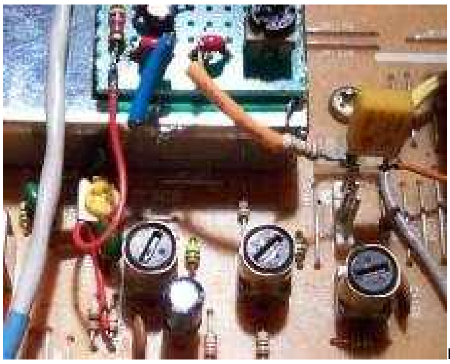
If the bandpass is not 12 kHz and the frequency is too high you will need to adjust the mixing frequency Cf by using C11.

If the bandpass does not reach 12kHz because of the mixing frequency being too low you will need to add a capacitor in series with the ceramic resonator Cf, something between 100pF and 300pF. I would recommend starting with 150pF (or use a trimmer).

Power source voltage

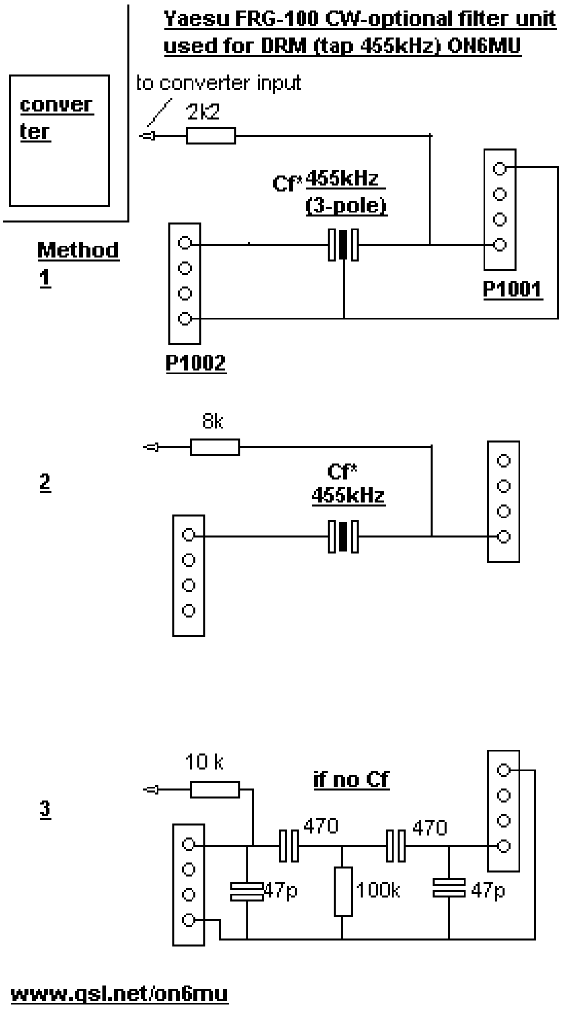
The converter Vcc voltage can be tapped from just about anywhere in the FRG-100. You can use the 12 volt input, or tap from the 9volts running allover the board. Tap often used is R1074 (closest to the front to the UB connection of the mixer board) where you find +9volt.
Any voltage from 8 to 18 volts can be fed as the converter uses a 78L06.

Using the CW/N optional filter connections


red wire is the +9v tapped from R1074, 47k resistor and ceramic filter is connected to the CW/N filter connector to get MF

It is perfectly possible to use the CW/N filter connections of the FRG-100 to tap the MF 455kHz...465Khz to feed it to our converter/mixer.

Use a 455kHz filter of 12...50kHz (often found in those old FM transistor radios etc.). This is soldered between pin 1 (top one) of CW/N filter connector P1002 and pin 4 of P1001 (bottom pin). A 47k resistor from P1002 pin 1 is fed to the input of the converter.
If you can not find such a ceramic filter (doubt it) you can replace it by a few caps (this is not a drop-in replacement, but workable enough to use for DRM with good signals till better is found).



Note: DRM-mode is selected by selecting CW/N mode.

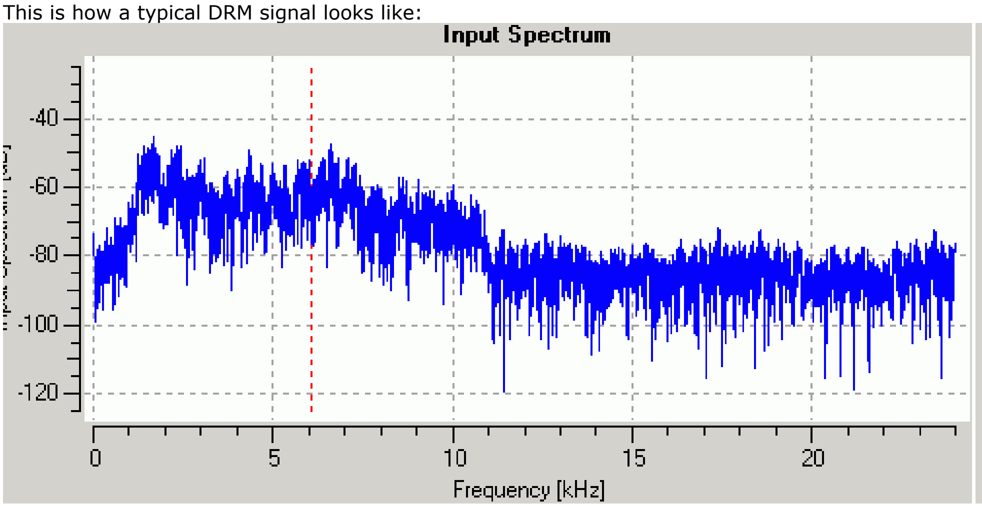
I soldered several of the converter grounds to the VFO chassis (approx. middle of the picture)
You can see the yellow/greenish 455kHz 20kc ceramic filter (between the converter and the FM-unit)
On the right side you can see my homemade FM-module based upon the Yaesu schematic found in the manual.

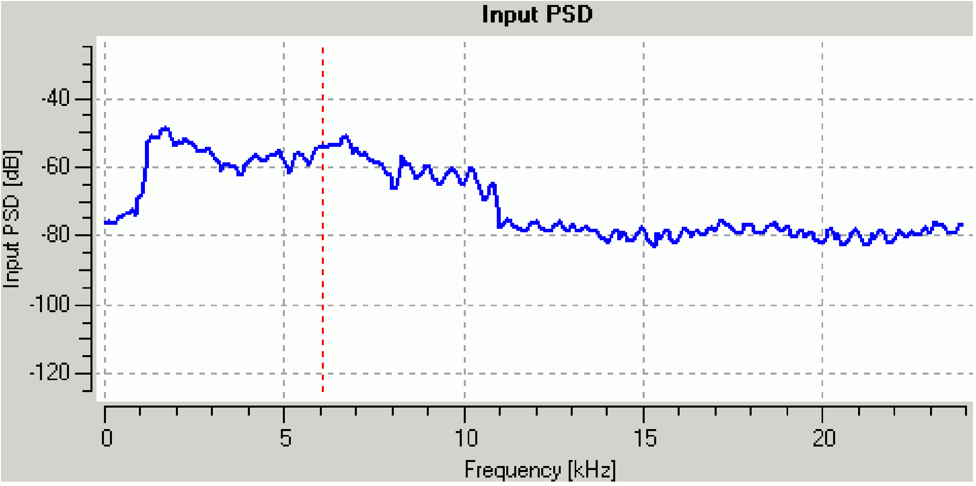
Output/tuning/setting

The output of the converter is fed to your soundcard using a female connector (on the backside of the receiver). I drilled a hole at the back of the FRG-100 to mount a 3.5mm female connector.
Use shielded wire to connect the converter to the connector.
R3 sets the maximum level of the MF signal supplied, hence adjusting R3 can improve the signal-to-noise ratio depending on the input sensitivity of your soundcard and/or do to the MF voltage

input. Set R3 to 80% to start with. Adjust the adjustment on the mixer board for a DRM-signal of approximately 50mV RMS.

This is how a typical DRM signal looks like:





- Connect the decoder software to the 12 kHz IF output of the converter.
- Set the input volume of your PC properly.
- Set your FRG-100 to CW/N mode.
- Tune to a good DRM signal (3995,5955,6095,13810Khz...).
  Note: I have found that by tuning +/- 2Kc of the DRM signal, the quality improves. Possible reason could be the sound card timing accuracy, or the LO frequency is not exact. Experiment!
  Note: To decode a DRM signal, the signal strength needs to be high and the S/N ratio has to be at least above 12dB
- Once you here the software decoding the DRM-signal you can further tweak the settings as explained above. And, the software itself has several settings that can improve the reception/decoding capabilities.

Some examples of decoded DRM signals using this converter/mixer and a Yaesu FRG100

- **Example 1a of a decoded DRM signal** - ideal reception conditions!
- **Example 1b of a decoded DRM signal** - medium ideal reception conditions!
- **Example 2 of a decoded DRM signal** - medium ideal reception conditions!
- **Example 3 of a decoded DRM signal** - bad reception conditions!

Software

DRM

Dream
http://drm.sourceforge.net
Dream - to decode DRM signals: Dream v1.16 compiled version

The necessary Qt runtime library "qt-mt230nc.dll" can be downloaded at:
http://prdownloads.sourceforge.net/netclipboard/qt-mt230nc.dll?download

Optional download: AMSchedule.ini
Get the current shortwave broadcasting schedule for AM stations from:
http://drm.sourceforge.net/download/AMSchedule.zip

Other DRM software: http://home.arcor.de/carsten.knuetter/drm.htm
SoDiRa
Free Software Radio (also good for DRM)
Tip: choose in Config->Receiver->Type: DSR30
http://www.dsp4swls.de/sodira/sodiraeng.html

WinRadio
Commercial DRM Demodulator/Decoder for Windows 2000, XP and Vista
Tip: Choose general-purpose DRM Software Radio (DRM demodulator/decoder for third-party receivers)
http://www.winradio.com/home/download-drm-2.htm

SDR

MDSR
MDSR is a powerful and free SDR capabale package.
homepage

HDSDR Homepage
HDSDR is a freeware Software Defined Radio (SDR) program for Microsoft Windows 2000/XP/Vista/7/8.
download
Typical applications are Radio listening, Ham Radio, SWL, Radio Astronomy, NDB-hunting and Spectrum analysis.
HDSDR (former WinradHD) is an advanced version of Winrad, written by Alberto di Bene (I2PHD).

SDRadio:
SSB, CW and AM demodulator: http://www.sdradio.eu/sdradio/
By I2PHD and IK2CZL, practic skin, made for für I/Q direct mixing concepts,
demodulates also by set an offset of middle frequency
to 12 kHz single IF very well. Can handle 40kHz+

G8JCFSDR:
Software defined radio using MF: http://www.g8jcf.dyndns.org/g8jcfsdr/
By G8JCF, good AM, better SSB and CW demodulator, also software AGC.
Several filter and noise reduction equipment. Also recorder mode supported.
http://www.g8jcf.dyndns.org/g8jcfsdr/

SM6LKM:
A Soundcard Based SAQ VLF Receiver:
http://web.telia.com/~u33233109/saqrx/saqrx.html

SoDiRa
Free Software Radio (also good for DRM)
http://www.dsp4swls.de/sodira/sodiraeng.html

SDRadio
I2PHD's SDRadio can be downloaded from here:
http://www.sdradio.org/

IFDSP
IK2CZL's IFDSP can be downloaded from here:
http://www.detomasi.it/en/project.html

DRM reception with the Yaesu FT-817

We use the optional CW or SSB Filter slot in the main unit. You must have this slot free (no optional filter) for using DRM on this radio.
The 455 KHz Signal for the DRM mixer can be easy taken from the first pin (from right) of J21 connector and connect the ground of cable to the second pin.
Now put a 455kc resonator between the first right pin of J20 and the first right pin of J21. Note:

You can use simular like used in the FRG-100 please see fig2.
If you do not have a 455kc resonator then a capacitor of +/- 120 pf will be do, but you loose the agc advantages.

Switch on the rig and enter in the Menu System (press and hold the [F] key for on second) and choose Menu Item 38 [OP FILTER] setting mode CW.

You can activate now the DRM reception using the function NAR of the operation menu and setting CW MODE.

DRM reception with the Yaesu FT-897

Look for the slots for optional CW or SSB filter (backside, left) It's labelled: J24 and J23.
Bridge the left two pins of J24 – so the software will use this slot as if the SSB filter is installed.
Put a 455kc resonator between the right pin of J24 and the right pin of J23. The third pin of J23 is connected to ground.
If you do not have a 455kc resonator then a capacitor of +/- 120 pf will be do, but you loose the agc advantages

Connect the DRM converter to the two right pins of J23 (ground and 455 kHz IF in).
I tapped 13 volts from the 8 volt voltage regulator (see on photo lower right corner). This connection is in consistency with the power on/off state of the rig.
For using the converter you have to enable the 2.3 kHz optional Filter setting in Menu (that's the reason for the J24 jumper)

drm using a FT-897

Tips

* This converter can also be used to feed a LF-amplifier (listen to signals unfiltered)
* Works with some software defined radio (SDR) programs, like SDRadio from I2PHD!
* Use it to analyse wide band spectrum
* Modify the converter to allow even wider bandwidth by changing the resonating ceramic filter.
* Can of course be used by any receiver that has a 455kHz MF you can tap.

More about the SA602 (NE602,SA612,NE612,SA162) in this project

The SA602A is a Gilbert cell, an oscillator/buffer, and a temperature compensated bias network as shown in the equivalent circuit. The Gilbert cell is a differential amplifier (Pins 1 and 2) which

drives a balanced switching cell. The differential input stage provides gain and determines the noise figure and signal handling performance of the system.
The SA602A is designed for optimum low power performance. When used with the SA604 as a 45MHz cellular radio second IF and demodulator, the SA602A is capable of receiving -119dBm signals with a 12dB S/N ratio. Third-order intercept is typically -13dBm (that is approximately +5dBm output intercept because of the RF gain).
Besides excellent low power performance well into VHF, the SA602A is designed to be flexible. The input, RF mixer output and oscillator ports can support a variety of configurations provided the designer understands certain constraints, which are explained here.

50Mc converter de ON6MU
SDRadio
FRG-100 audio improvement
Dream v1.16 compiled version
Example of a decoded DRM signal

Technical graphs:

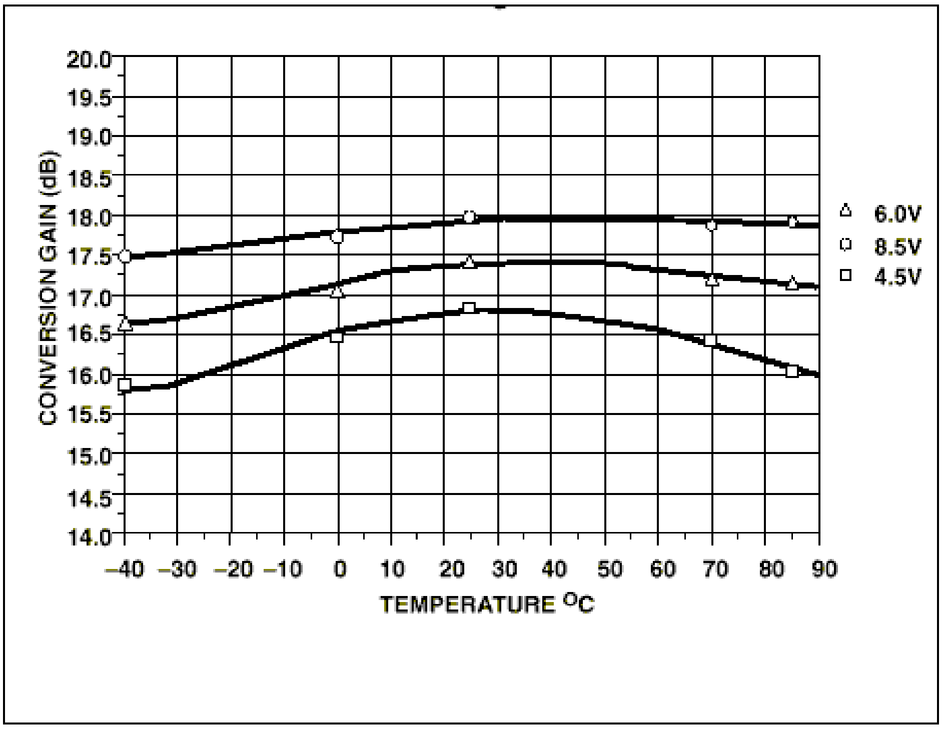


Figure 3 . Conversion Gain vs Supply Voltage

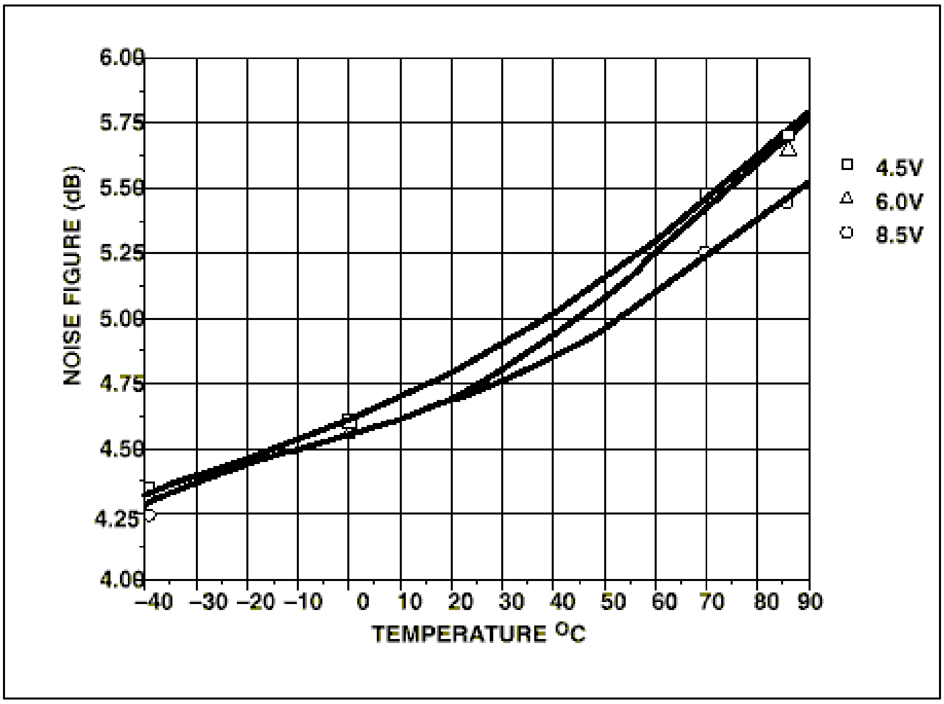
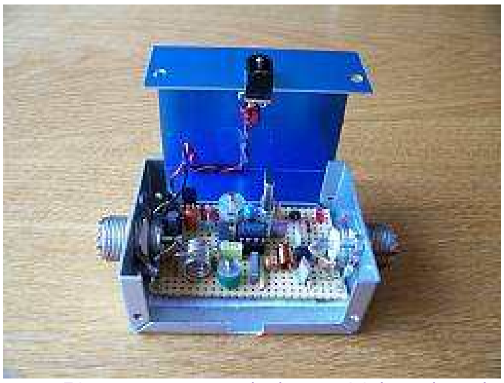


Figure 5. Noise Figure

Please also look at our [Digital Analog Demodulation Project](#) (DADP, VE7DXW) that explains in high detail how to use it for the Yaesu FT-817 and simular transceivers

More about these mods:

Youtube:
This is how Tonino IZ6QTX made it and how he is using it:
http://www.youtube.com/watch?v=VoKhKqP2duM
http://www.youtube.com/watch?v=5MvFH9X5kpU
Thank you Tonino!



Please take a look at my 50MHz converter which is ALSO based on the SA/NE 602 mixer!

My E-mail

Note: if you want to commercialise, publish or distribute this project then you need to ask permission to do so.

Attention! The modification will be done at your own risk!

[home]

[mail] [shack] [homebrew] [software] [satellite]
[haminfo] [mods]

Back to ON6MU **Homepage**

Four types of Homebrew 12/20/30 Ampere 13,8volt power supplies: RE PSF14A12D, PSF14A20D, PSF14A20 and PSF14A30

RE-PSF14A12D

revision 4

By Guy, de ON6MU

This is an easy to make power supply which has stable, clean and protected output voltage. The overal dimensions can be kept (relative) small by using TO220 darlington BDX-33 transistors. Using 3 BDX-33 darlington transistors is almost 3 times the amount of amps then the power supply delivers, making it real though to brake ;). Although you could use this design to deliver 20 amps (with almost no modifications and with a proper transfo and a huge heat sink with a fan), I did not needed such much power. Second reason was the size of the alu box I happen to have spare HI. There was simply not enough room for the transformer, and surely not enough space to mount a huge heat sink, as the BDX33 transistors can get very hot, and they do not like that so much.
It is obvious, but I would like to mention that you could make this power supply with less BDX-33 transistors if you do not need high power.

Although the 7815 power regulator should kick in on shortcircuit, overload and thermal overheating, I build in a very simple secondary overvoltage protection that's made out of 12 volt relay. The rectified voltage of: 15 volt x SQR2 = 15 x 1.41 = 21.15 volt measured on C1. This is the voltage that could be on the output if one of the transistors should blow. We need a little calculation to get the exact voltage (or higher) to power the 12volt relay which should disconnect the output. In this example we use for diode Zd 9v/5watt -> 21v - 9v = 12 volt. To allow the relay to disconnect the output on lower voltages, use a lower voltage for diode Zd. You could use a different voltage relay too, but diode Zd should be calculated to allow the relay to work just when the output voltage rises over 16 volt + (Zd in the schematic).
Remember that the relay needs to be able to switch 12 amps (or more). If the relay offers multiple switches then please use them. The more the better (also less resistance hence voltage drop when loaded).

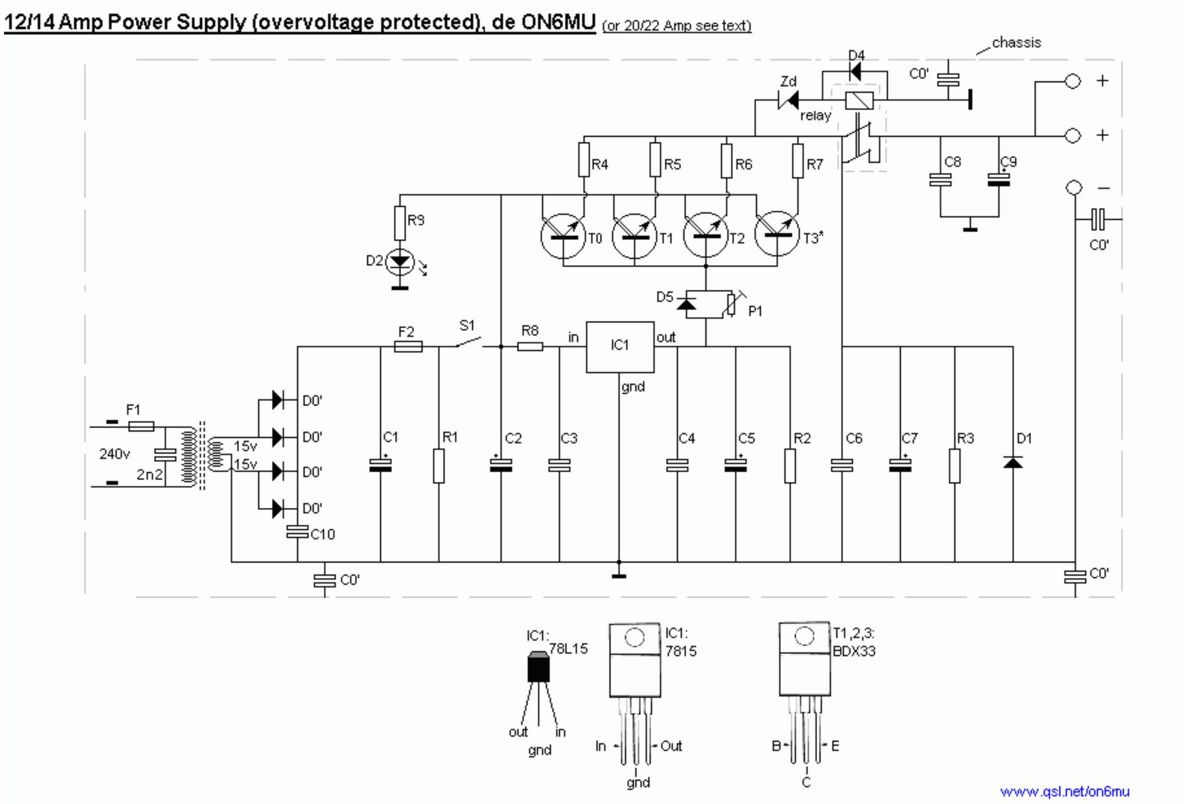
P1 allows you to 'trim' the output voltage exactly to 13.8 volts.

Remember to isolate the transistors from the chassis/radiator! This is very important! Use a radiator (heat sink) of appropriate size and surface area; insulating and heat-conducting spacer or at least a thin mica; hot adhesive and thermal paste. Use thick wires.

Just to be sure to prevent HF entering (or going back to the mains) use a ring core to turn the mains a few times around it (see insides pics).

Revision 3
. Zd was wrongly connected after the relay switch instead of before
. C5 changed to 330uF to improve ripple rejection and stabelisation
. primary side of the transformer added 250v/2n2 decoupling cap
. P1 = 500Ohms or 1k trimmer is sufficient
. reversed diode over IC1 removed

RE-PSF14A12 Power supply Schematic 1



Part list PSF14A12D
12 Amp BDX33-based power supply:

- 2 x 15 volt 6+ amps
- 2 times two MR750 (MR7510) diodes (MR750 = 6 Ampere diode) or 2 times 3 1N5401 (1N5408) diodes.
- F1 = 1,5 (2) Amp
- F2 = 15 amp
- R1 2k2 1 Watt
- R2 10k
- R3 1k 0.5 watt
- R4,R5,R6,R7 0.1 ohm 5 watt
- R8 4.7
- R9 6k8
- C1 two times 4700uF/35v
- C2,C5 330uF/35v (revision 2: C5 = 330uF -> improved ripple rejection and stabelisation)
- C0',C3,C4,C6,C10 100nF
- C7 330uF/25v
- C8 47nF
- C9 47uF/25v
- D1 1N5401
- D2 LED
- D4, D5 1N4001
- IC1 78L15
- relay 12 volt 2x5 amp switching
- 3 darlington transistors: T0,T1,T2 = BDX-33 NPN TO-220 transistor
- Zd 8 or 9 volt, 5 watt

- P1 1k trimmer

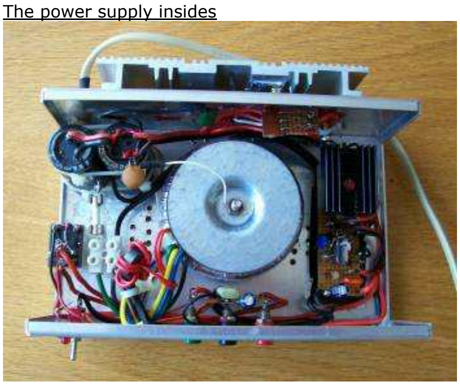
If using a bridge rectifier (like in schematic 2) you do not need 2 x 15 volts 6 amps, but 1 x 15 volt 10+ Amps

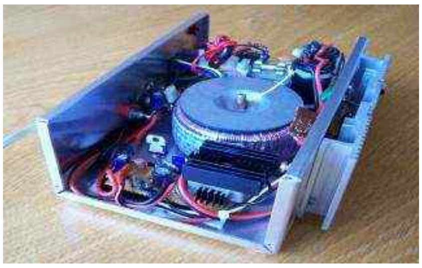
Part List PSF14A20D
20 Amp BDX33-based power supply:

- 2 x 15 volt 12+ amps
- 2 times 3 MR750 (MR7510) diodes (MR750 = 6 Ampere diode) or 2 times 5 1N5401 (1N5408) diodes.
- F1 = 3,18 Amp
- F2 = 25 amp
- R1 2k2 1 Watt
- R2 10k
- R3 1k 0.5 watt
- R4,R5,R6,R7 0.1 ohm 10 watt
- R8 4.7
- R9 6k8
- C1 22000uF/35v
- C2, C5 330uF/35v (revision 2: C5 = 330uF -> improved ripple rejection and stabelisation)
- C0',C3,C4,C6,C10 100nF
- C7 330uF/25v
- C8 47nF
- C9 47uF/25v
- D1 1N5401
- D2 LED
- D4, D5 1N4001
- IC1 7815
- relay 12 volt 10 amp switching
- Four darlington transistors: T0,T1,T2,T3 = BDX-33 NPN TO-220 transistor
- Zd 8 or 9 volt, 5 watt
- P1 2k trimmer

If using a bridge rectifier (like in schematic 2) you do not need 2 x 15 volts 12 amps, but 1 x 15 volt 20 Amps

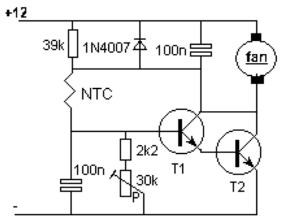
The power supply insides





A simple temperature controled fan:

Temperature controled fan kept simple. de ON6MU



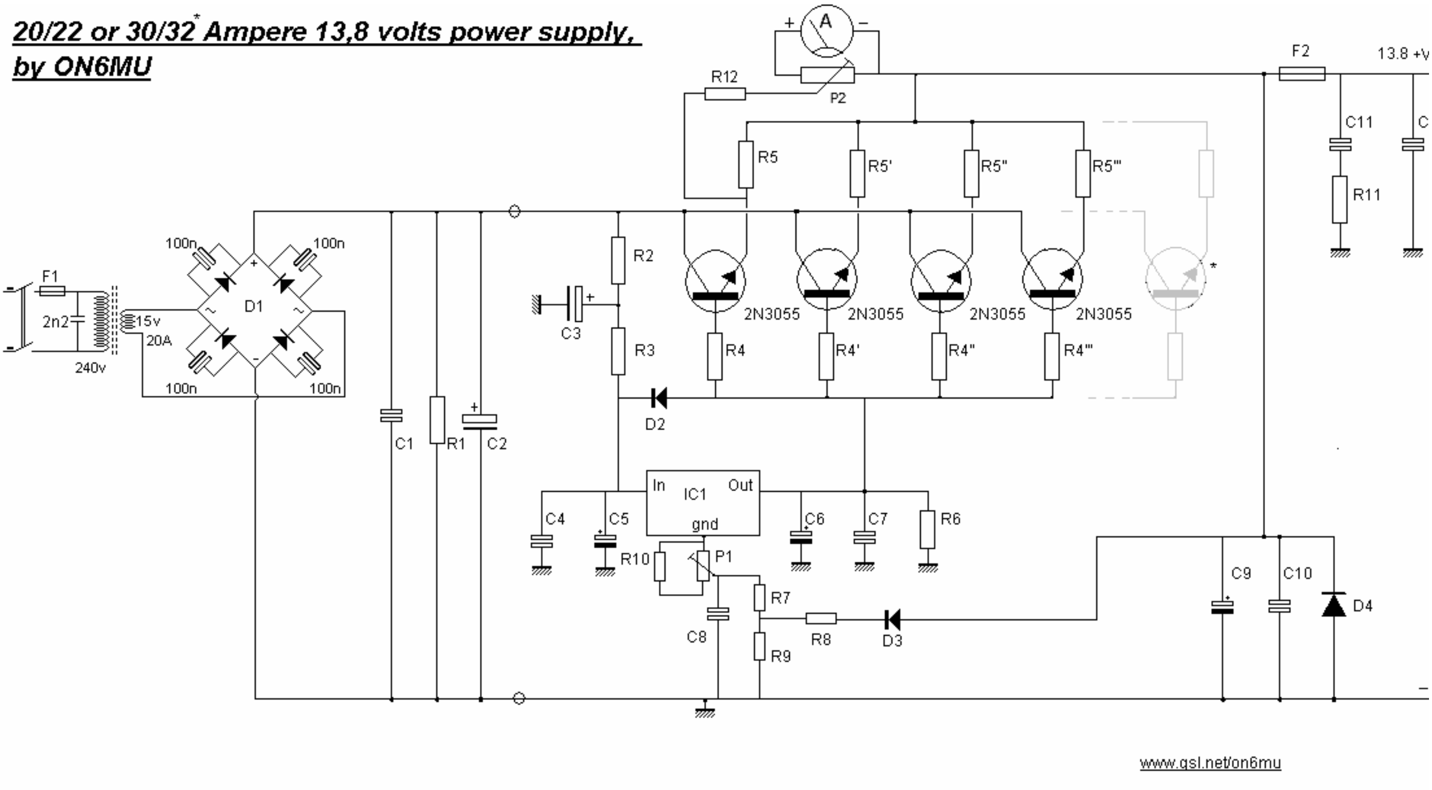
Temperature controled fan

T1 =BC338,BC337
T2 = BD137,BD139... If the fan uses less than 250mA a simple BC338 can be used (often a small CPU fan.)
NTC= +/- 30k (not critical, any NTC between 5...60k works)
P = set temperature when the fan needs to work.
You can also set the fan to rotate slowly constantly as the schematic will kick in when the temps get too high hence letting the fan speed up.

www.qsl.net/on6mu

20/22 Ampere or 30/32 Ampere 13.8 volts power supply
RE-PSF14A20 or PSF14A30
de ON6MU

RE-PSF14A20
Power Supply Schematic 2 (new design) revision 2014



Remember to isolate the 2N3055 transistors from the chassis/radiator! This is very important! Use a radiator (heat sink) of appropriate size and surface area; insulating and heat-conducting spacer or at least a thin mica; hot adhesive and thermal paste.

PSF14A20 Specs

- Heavy duty power supply 13.8 volt, 20 or 30 amps continue
- low ripple
- short-circuit protection
- HF-immunity
- Voltage can be set between 12,3 and +/- 15 volts
- only 0.35v drop at full load
- parts widely available and calculated way over the maximum load

PSF14A20 Parts (30 amp version PSF14A30 in blue)

- transformer capable of delivering 20 amps @ 15volt (30 amps)
- 4 x 2N3055 (6 x 2n3055) (you can also use the 2N3773 transistor)
  Use a large radiator (heat sink) of appropriate size and surface area; insulating and heat-conducting spacer or at least a thin mica; hot adhesive and thermal paste.
- IC 1: 7812 (small heatsink)
- D1: MB2504 is used as it is a 25 ampere rectifier bridge and should also be very good cooled.
  Or you could use 3 times four BYW29 8 amp diodes (TO220 pinning, cooling).
- D2 & D3: 1N4001 or simular
- D4: 1N5401 or simular (1N5400...1N5408)
- C1: 47nF
- C2: 22000uF (+ 10000uF) 35volts
- C3: 100uF/35volt

- C4: 100nF
- C5: 4.7uF/35volt
- C6: 4.7uF/35volt
- C7: 100nF
- C8: 220nF
- C9: 220uF/25volt
- C10: 47nF
- C11, C12: 100nF
- R1: 2k2 / 1W
- R2: 10 1/2W (2,2 1/2W)
- R3: 6,8 1/2W (2,2 1/2W)
- R4': 1 Ohm 1/2W
- R5': 0.1 Ohm/5W
- R6: 2k2
- R7: 10
- R8: 2k2
- R9: 22
- R10: 1k5
- R11: 10
- R12: 220
- P1: 1k
- P2: 2k2 trimmer (to calibrate the meter that will be used to measure the amps)
- F1: 2A (3.18A)
- F2: 22A (35A)

P1 allows you to 'trim' the output voltage exactly to 13.8 volts.
Just to be sure to prevent HF entering through the mains use a ring core and turn the mains a few times around it (see insides pics).
Be sure to use thick braid wires!!! They need to handle 20 (30) amps continues!

Total revision changes:

. highly improved voltage stabilisation
. output voltage feedback circuit stabilisation
. BDX-33 removed
. Cap after 7815 changed from 1uF to 4.7uF
. Resistors before the input of the 7815 changed
. reverse diode (between collector and emittor of 2n3055) removed
. voltage can be set exactly to 13.8v (P1)
. minor HF-immunity changes
. reversed diode over IC1 removed

Revision 2016:

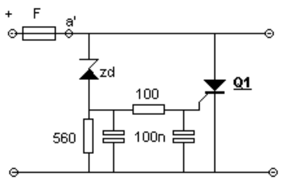
. R10 changed 1k5, and P1 to 1k (thanks Goran 9A6C)
Goran reported that he could not reach 13.8 volts using a 500 Ohm potentiometer(P1) parallel with the 1k resistor(R10).
Replacing P1 & R10 with fixed resistor of 680 Ohm would give approx. 13.6 volts.

. Revision 2017: added ampere meter without using the meter in series (P2 trimmer to calibrate the meter that will be used to measure the amps)

Overvoltage protection:

A crowbar circuit is an electrical circuit used to prevent an overvoltage condition of a power supply unit from damaging the circuits attached to the power supply. It operates by putting a short circuit or low resistance path across the voltage output (Vo), much as if one were to drop a crowbar across the output terminals of the power supply. Crowbar circuits are frequently implemented using a thyristor, TRIAC, trisil or thyratron as the shorting device. Once triggered, they depend on the current-limiting circuitry of the power supply or, if that fails, the blowing of the line fuse or tripping the circuit breaker.

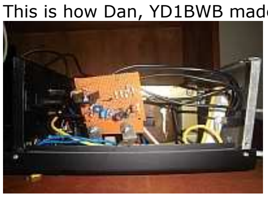
The 'CROWBAR' overvoltage protection circuit (RF blocked)



Zd = zener xx Volt - maximum voltage to allow. For 12v PSU use Zd of 15v or 16v
Q1 = thyristor powerful enough to peak surge the current that the power supply delivers (times 10) hence blowing the fuse. Example:BTW69-600 (peak 600 Amp!)
Important: Be sure the power supply has a correct fuse!!

Pictures of people who made the PS

This is how Dan, YD1BWB made it:





click on the images to enlarge

Thanks Dan!

Links of interest:

ON6MU Homebrew projects
Radioamateur related projects
ON6MU 78h05 powersupply
Versatile 7805 based 5Amp powersupply

Home
www.qsl.net/on6mu

ON6MU

Three types of multi-functional Homebrew 10-, 20- and 30 Ampere regulatable power supplies: RE PSR28A10, PSR30A20 and PSR30A30

RE-PSR28A10

By Guy, de ON6MU

This is an easy to make power supply which has stable, clean and regulatable output voltage. By using a MOSPEC MJ15003G transistor which is capable of delivering 20A which is 2 times the amount of amps the power supply is designed for, making it really though to brake ;). Make sure you mount the transistor on a huge heat sink. Also use thick wires.

Although the LM-317 power regulator will kick in on shortcircuit, overload and thermal overheating, the fuses in the primary section of the transformer and the fuse F2 at the output will secure your power supply. The rectified voltage of: 30 volt x SQR2 = 30 x 1.41 = 42.30 volt measured on C1. So all capacitors should be rated at 50 volts. Caution: 42 volt is the voltage that could be on the output if one of the transistors should blow.

P1 allows you to set the output voltage to anything between 0 and 28 volts. The LM317 lowest voltage is 1.2 volt. To have a zero voltage on the output I've put 3 diodes D7,D8 and D9 on the output of the LM317 to the base of the MJ5003J transistor. The LM317 maximum output voltage is 30 volts, but using the diodes D7,D8 & D9 the output voltage is approx 30v - (3x 0.6v) = 28.2volt.

Calibrate your build-in voltmeter using P3 and, of course, a good digital voltmeter.

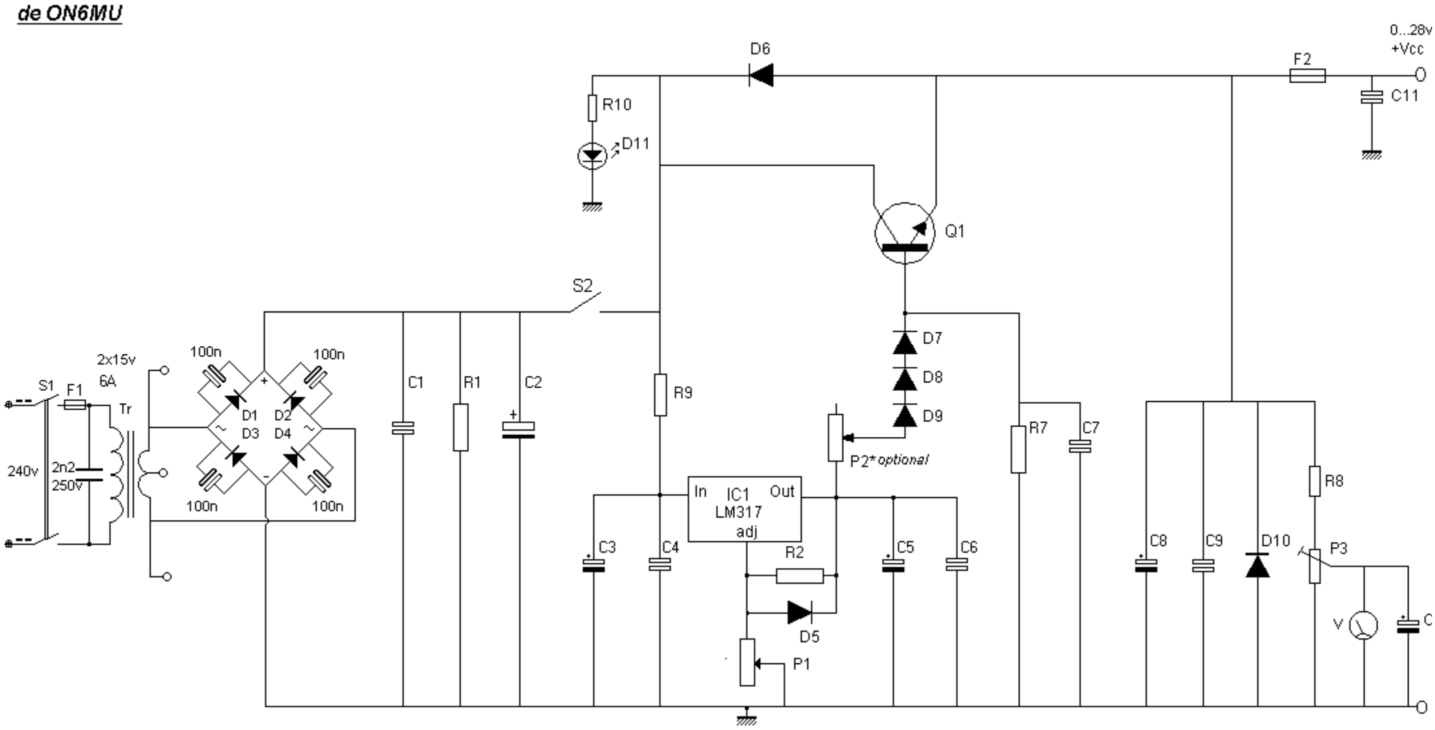
P2 will allow you to set the limit of the maximum available amps at the output +Vcc. When using a 100 Ohm/1watt varistat the current is limited to approx. 3 Amps @ 47 Ohm and +- 1 Amp @ 100 Ohms. You can leave it out completely if no limmiting is needed.

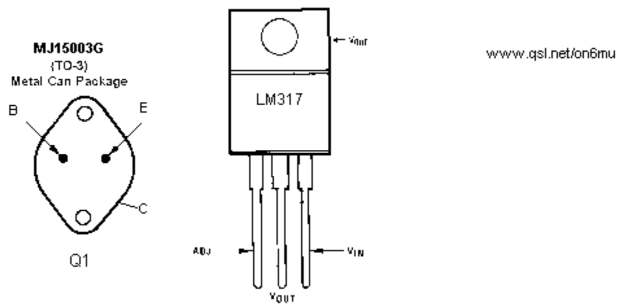
Note:
Be sure you isolated the transistor from the heatsink if you are using a metal casing where you electrically mount the heatsink to it.
Remember to use thick wires suitable for transfering the current needed according to the power supply you tend to build.

RE-PSR28A10 Power supply Schematic 1

10 Ampere 0...28 volt regulated power supply

de ON6MU





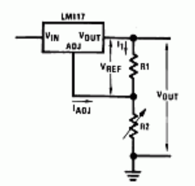
Part list for 6/8 Amp regulatable power supply (PSR28A68):

- 2 x 15 volt (30volt total) 8...10 amps
- D1...D4 = four MR750 (MR7510) diodes (MR750 = 6 Ampere diode) or 2 x 4 1N5401 (1N5408) diodes.
- F1 = 1 Amp (slow)
- F2 = 12 amp
- R1 2k2 2,5 Watt
- R2 240 ohm
- R7 6k8
- R8 10k
- R9 39 0.5 watt
- R10 8k2
- C1,C7,C9 47nF
- C11 22nF
- C2 10000uF/50v
- C3,C5 10uF/50v
- C4,C6 100nF
- C8 330uF/50v
- C10 1uF/16v

- D5 1N4148, 1N4448, 1N4151
- D11 LED
- D6, D7, D8, D9, D101N4001
- IC1 LM317
- MJ15003G MOSPEC transistor
- P1 5k
- P2 47 Ohm or 220 Ohm 1 watt *
  (be sure you can reach 0 ohms as any resistance limits the current)
  note:*This way of limiting the current is very basic, not an accurate way. To really get an accurate current limitter we need to modify the schematic around the LM317. P2 has been used to show a simple way of limitting, it is not the ideal way, but it works. When I have time I will look into this and place an update on the website.*
- P3 10k trimmer
  Calibration:
  - Get your hands on a calibrated digital meter or a good analog meter and measure the voltage at the output of the power supply.
  - Turn P1 to maximum (maximum voltage of our power supply).
  - Adjust P3 till the meter needle shows maximum result (end scale)
  - If you want to calibrate the scale, turn P1 to several voltages (like every volt) and confirm each time with your calibrated voltage meter. Make a mark on your power supply meter-scale to calibrate the meter.
  - You should see equal spaced voltage marks on your home-made scale if your meter is a linear type.

Less maximum output voltage needed?
In operation, the LM317 develops a nominal 1.25V reference voltage, VREF, between the output and adjustment terminal.
The reference voltage is impressed across program resistor R1 and, since the voltage is constant, a constant current I1 then flows through the output set resistor R2, giving an
output voltage of

$$V_{OUT} = V_{REF}\left(1 + \frac{R2}{R1}\right) + I_{ADJ}R2$$



Since the 100 uA current from the adjustment terminal represents an error term, the LM317 was designed to minimize IADJ and make it very constant with line and load changes.
To do this, all quiescent operating current is returned to the output establishing a minimum load current requirement. If there is insufficient load on the output, the output will rise.

Less amps needed?
Well, without much modification you can:
- only one 2N3055, will give you 5 amps and have some amps/power to spare.
- the bridge rectifier (D1...D4) only needs 4 x 1N5401 (any +/- 3 amp diodes as only halve of the max. amp is needed, so we have some room when short-circuited)
- one 4700uF (C2) is sufficient
- F2 = 6 amp
- D5, D10 = 1N4001

The power supply insides

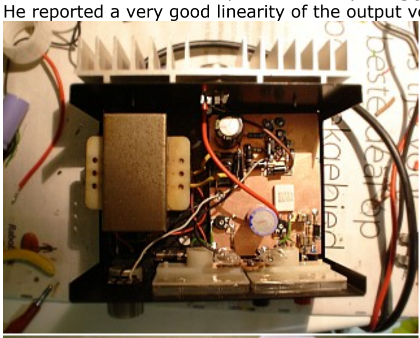
Heat sink

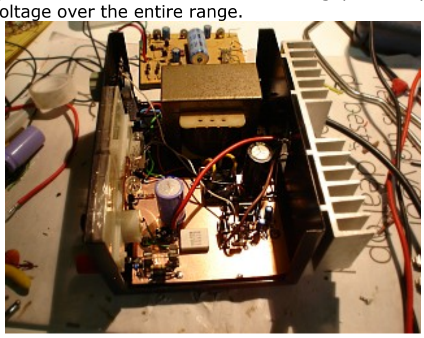
Remember to isolate the transistors from the chassis/radiator! Use a radiator (heat sink) of appropriate size and surface area; insulating and heat-conducting spacer or at least a thin mica; hot adhesive and thermal paste.

Finished power supply:

This is how Oakkar7 made it (using a PC power supply chassis too!) :
Must see: http://okelectronic.wordpress.com/2011/07/08/diy-variable-workbench-power-supply/

Mark, PA4M, made a 3 ampere version by using just one 2N3055 and build into a Zetagi power supply box.
He reported a very good linearity of the output voltage over the entire range.



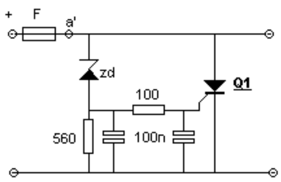


Thanks Mark for the feedback and pictures!

Overvoltage protection:

A crowbar circuit is an electrical circuit used to prevent an overvoltage condition of a power supply unit from damaging the circuits attached to the power supply. It operates by putting a short circuit or low resistance path across the voltage output (Vo), much as if one were to drop a crowbar across the output terminals of the power supply. Crowbar circuits are frequently implemented using a thyristor, TRIAC, trisil or thyratron as the shorting device. Once triggered, they depend on the current-limiting circuitry of the power supply or, if that fails, the blowing of the line fuse or tripping the circuit breaker.

The 'CROWBAR' overvoltage protection circuit (RF blocked)



Zd = zener xx Volt - maximum voltage to allow. For 12v PSU use Zd of 15v or 16v
Q1 = thyristor powerful enough to peak surge the current that the power supply delivers (times 10) hence blowing the fuse. Example:BTW69-600 (peak 600 Amp!)
Important: Be sure the power supply has a correct fuse!!

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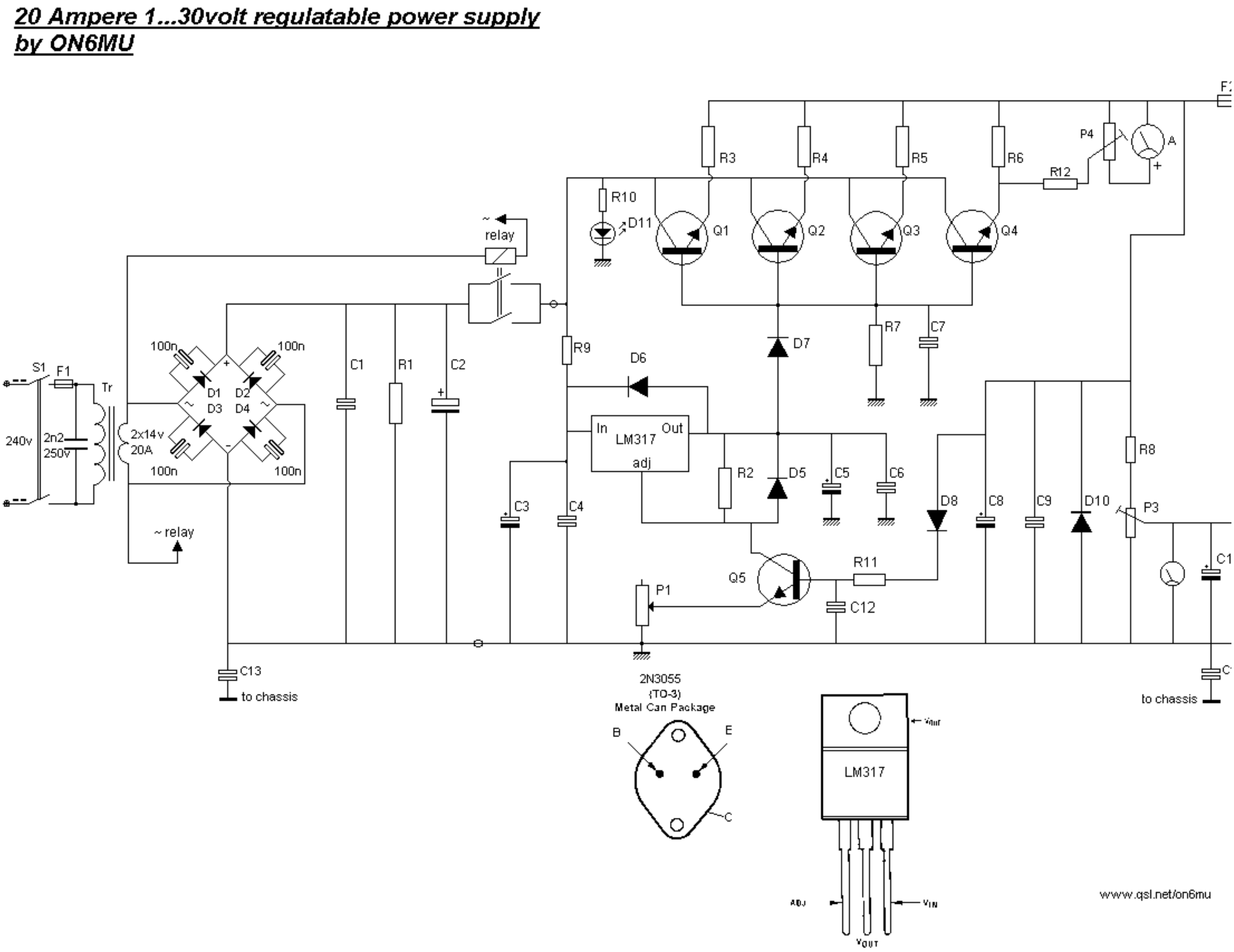
20 ampere regulatable power supply 1...30volt RE-PSR30A20

(total revision)

RE-PSR30A20 Schematic 2



Major revision of the entire project.

PSR30A20/30 Specs

- 1.35 volt ... 30 volts
- 20 ampere PSR30A20 (modify up to 30 amps PSR30A30)
- voltage stabilisation
- low ripple
- short-circuit protection
- option: current regulation
- HF immunity

Today's highlight!

Part list PSR30A20 or PSR30A30
20/30 Ampere regulatable power supply (30 amp version values in blue):

- 2 x 14 volt 20+- amps (30 amps)

- F1 = 2 Amp (4 amp)
- F2 = 25 amp (35 amp)
- R1 2k2 - 2,5 Watt
- R2,R12 240 ohm
- R3,R4,R5,R6 0.1 ohm 5 watt
- R7 6k8
- R9 10 1watt
- R8 10k
- R10: 10
- R11 4k7
- C1,C7,C9 47nF
- C2 five X 4700uF/50v or one 22000uF/50v
  C2 seven X 4700uF/50v or one 22000uF/50 + 10000uF/50v
- C3 10uF/50v
- C5 1uF/50v
- C4,C6,C10 100nF
- C8 220uF/50v
- C10 4.7uF/16v
- C11 2n2
- C12 22nF
- (C13,C14...100nF optional when using a metal chassis where the zero volt is islolated from)
- C15 100nF
- C16 10nF
- D1...D4= Bridge rectifier MB2504 (25 amps cooled)
  or eight BYW29 8 amp diodes (TO220 pinning cooled)
  or 8 x MR750 (MR7510) diodes (MR750 = 6 Ampere diode) or 16 x 1N5401 (1N5408) diodes.
- D5, D8 1N4148 (1N4448, 1N4151)
- D6 & D7 1N4001
- D10 1N5401
- D11 LED
- IC1 LM317
- Q1...Q4: Four 2N3055 transistors (six 2N3055) (you can also use the 2N3773 transistor)
- Q5 BC338, 2N2222, BC547
- P1 5k
- P3 10k trimmer
- P4 2k5 trimmer (to calibrate the meter at max current).
- optional: relay = 30 volts AC, 2x10 (3x10) amp switching

optional: *To get an accurate current limitter we need to modify the schematic around the LM317. When I have time I will look into this and place an update on the website.*

The relay is used to switch off the power supply voltage when the mains (S1) are/is switched off. So no delay do to the discharge of C2, and so preventing output voltages from not return to zero immediately. You can leave it out if you do not care about slow discharge of the voltage when turned off, or add a heavy duty secondary switch.

A MB2504 is used as it is a 25 ampere rectifier bridge which also should be cooled. Or you could use eight BYW29 8 amp diodes (TO220 pinning) mounted on a heat sink.

Mount a little heatsink on the LM317 IC. Be sure that C3, C4, C5 and C6 are mounted as close as possible to LM317!

Use heavy bread wires that can deliver 20/30 amps

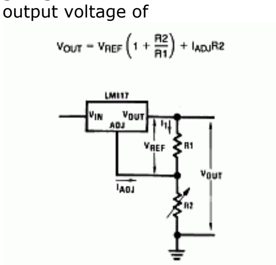
Remember to isolate the 2N3055 transistors from the chassis!
Use a radiator (heat sink) of appropriate size and surface area; insulating and heat-conducting spacer or at least a thin mica; hot adhesive and thermal paste.

20/30 amp needs proper large heat sink and remember to use pretty thick wires!
Note:
The collectors of the finals needs to be soldered with a wire all together if the transistors even if they are isolated from the heatsink or not. If you do not isolated the finals from the heatsink, then please make sure the heatsink does not make contact with the chassis (metal casing where you plan to build the PS into).

This revision has been improved with a feedback control on the output voltage (Q5, R11,C11,D8), giving increased stability. However, the lowest voltage is about 1.35v, while in the previous design (schematic 1) the voltage can by zero.
When problems with spikes or irregular voltage control then try to disconnect Q5 and take it from there.

Special thanks to *Andrew B.* concerning the feedback of the output voltage.

Less maximum output voltage needed?
In operation, the LM317 develops a nominal 1.25V reference voltage, VREF, between the output and adjustment terminal.
The reference voltage is impressed across program resistor R1 and, since the voltage is constant, a constant current I1 then flows through the output set resistor R2, giving an
output voltage of



Since the 100 uA current from the adjustment terminal represents an error term, the LM317 was designed to minimize IADJ and make it very constant with line and load changes.
To do this, all quiescent operating current is returned to the output establishing a minimum load current requirement. If there is insufficient load on the output, the output will rise.

More of my projects: 78h05_powersupply

This is how Ivan Lops made it:

click to enlarge
Many thanks Ivan!!

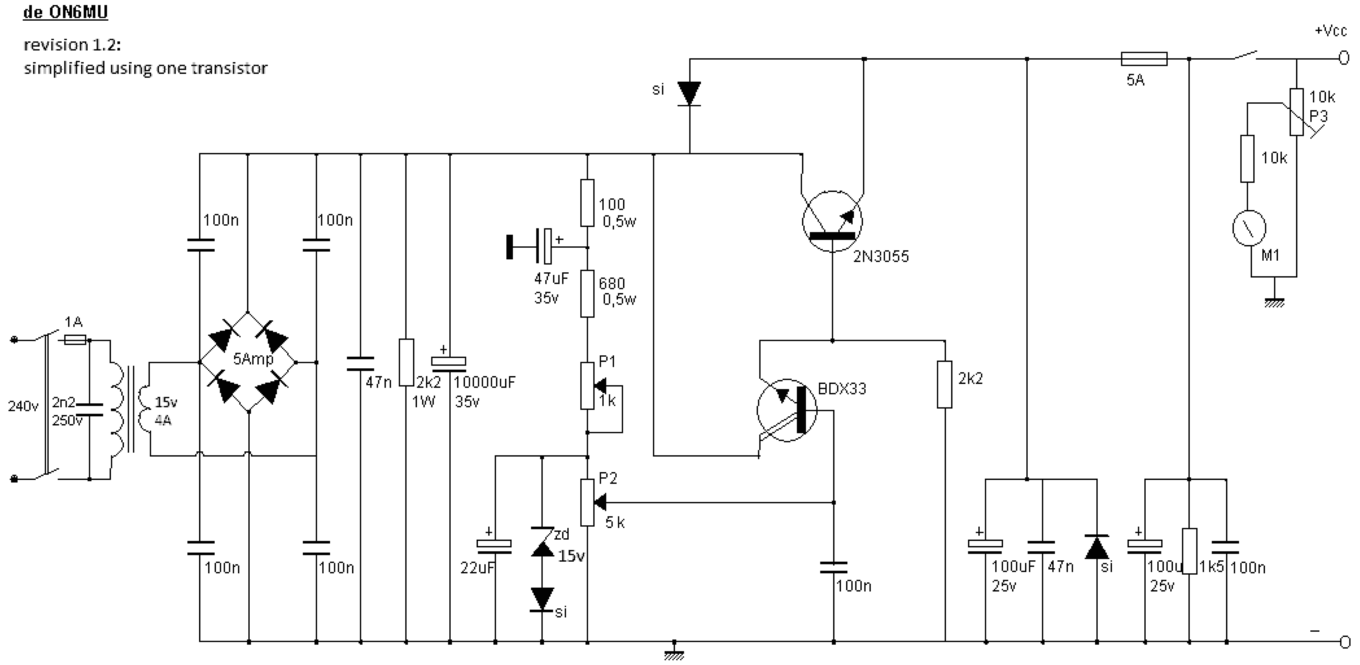
---

4 ampere regulatable power supply 1...15volt RE-PSR4A18

RE-PSR4A18 ***4 AMP regulated powersupply.***

de ON6MU

revision 1.2:
simplified using one transistor



P1 = sets maximum current (if do not need to be able to decrease amperage, remove P1

P2 = regulates output voltage between 0 and 15v DC.
P3 = trimmer to calibrate M1 voltage meter.

http://www.qsl.net/on6mu

Revision 2017
Using one transistor and removed coils and serie base resistor. P2 is reduced to 5k.
The powersupply can easily give 4 amps 24/24 and 5amps for an hour or two without any issues (peak 6A).

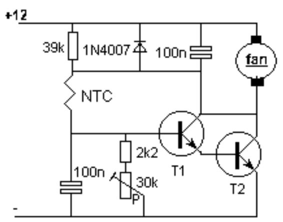
This how Morten LA9DNA build it:

click to enlarge
Thanks Morten!

A simple temperature controled fan:

Temperature controled fan kept simple. de ON6MU



Temperature controled fan

T1 =BC338,BC337
T2 = BD137,BD139... If the fan uses less than 250mA a simple BC338 can be used (often a small CPU fan.)
NTC= +/- 30k (not critical, any NTC between 5...60k works)
P = set temperature when the fan needs to work.
You can also set the fan to rotate slowly constantly as the schematic will kick in when the temps get too high hence letting the fan speed up.

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ON6MU

Using Wireless Networking Antennas

(first published January 2012)

Over the years, I have received quite a few emails from people, asking how they need to connect a biquad antenna, collinear antenna or some other antenna to their computer. This page is designed to provide that information - to clarify just how these antennas are typically used.

Connecting an Antenna

You cannot connect an antenna directly to your computer's USB socket or ethernet socket. You need a wireless radio to handle the 802.11b/g communications, and the antenna needs to be connected to this radio. In addition, the wireless radio also needs to be connected to your computer, to allow your computer to send and receive network traffic through the wireless radio.

Many wireless radios have built-in antennas or factory-attached antennas, typically low-gain rubber ducky antennas. In some cases, factory-attached can be removed, allowing you to connect a larger, higher-gain antenna to the antenna socket. You cannot use an external antenna with a wireless radio that has non-removable antennas, unless you want to open up the wireless radio and start hacking it with a soldering iron!

(If you are looking for a slight improvement in performance with the default rubber ducky antennas, then a parabolic reflector behind the rubber ducky may be sufficient.)

Pigtails

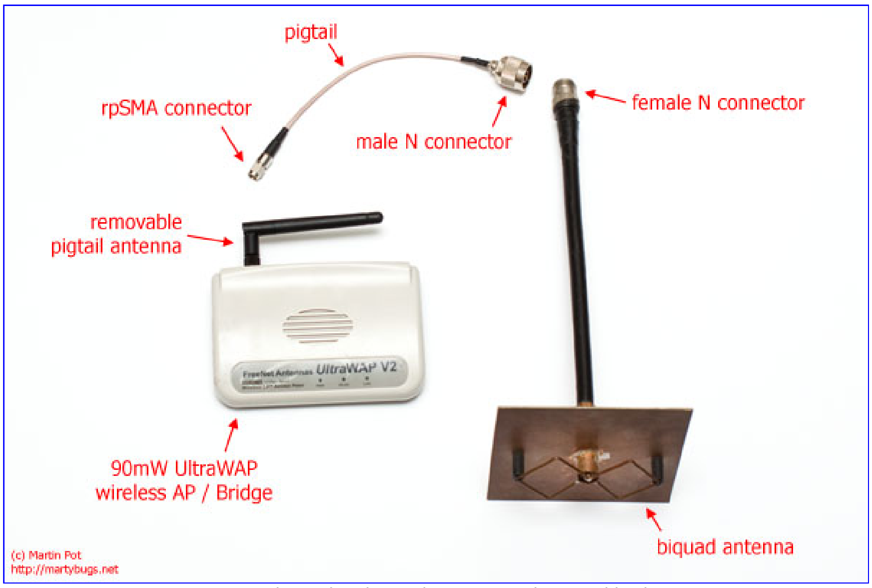
To connect an external antenna to a wireless radio, an appropriate adapter cable is also required. These cables are typically referred to as "pigtails", and many types are available. Get a short pigtail, as they are typically made from thin coax that has a relatively high attenuation (ie, loss).
You will need to get a pigtail with a suitable connector to suit the socket on your wireless radio, and the other connector on the pigtail needs to suit the one on your antenna. If you want to locate the antenna further away from the wireless radio, low-loss coax (such as CFD-400 / CNT-400) is recommended, to ensure you do not lose too much signal in cable losses.

Connecting to your Computer

The wireless radio also needs to be connected to your computer. This is typically done via an ethernet cable. For example, the UltraWAP shown in the images below has a single ethernet socket on it, allowing it to be connected to a single computer, or to an ethernet switch. The PCMCIA card shown below needs to be plugged into the PCMCIA socket typically found on laptops.

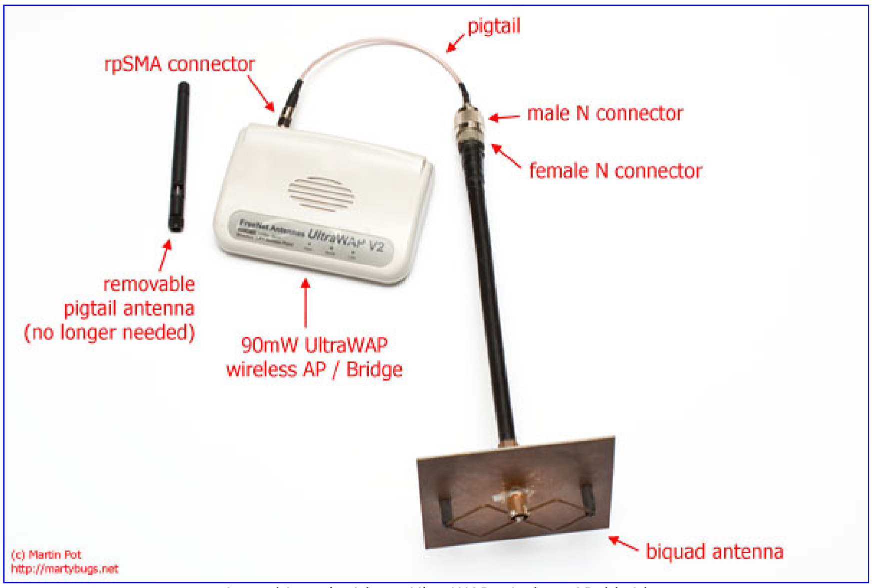
Example Usage Scenarios

The image below show the components needed to connect a biquad antenna to an UltraWAP 802.11b/g wireless AP/bridge. The biquad has a female N connector on the end of its short length of coax, and the UltraWAP has a removable rubber ducky antenna connected to an rpSMA socket.
An rpSMA to male N connector pigtail is required, and the factory rubber ducky antenna needs to be removed to allow the pigtail to be connected.



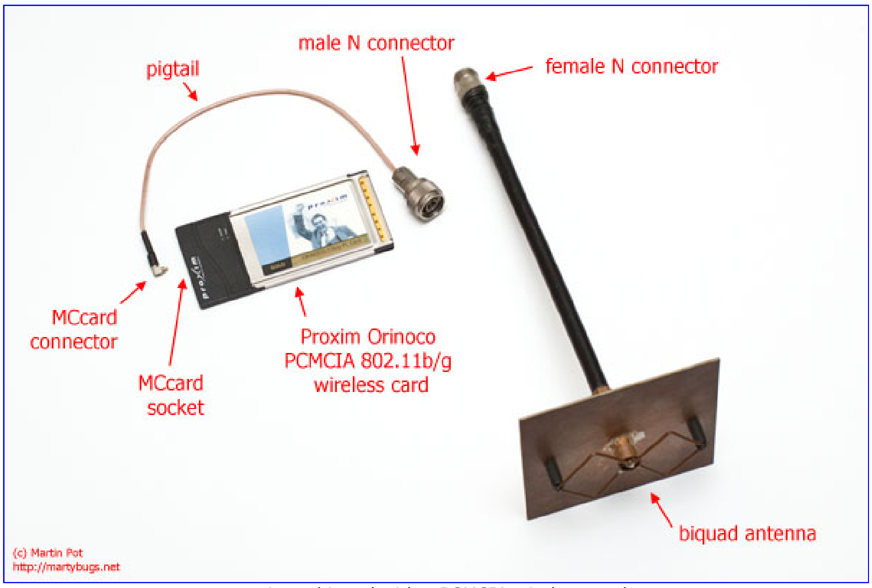
using a biquad with an UltraWAP wireless AP / bridge

The image below shows a biquad antenna connected to the UltraWAP.



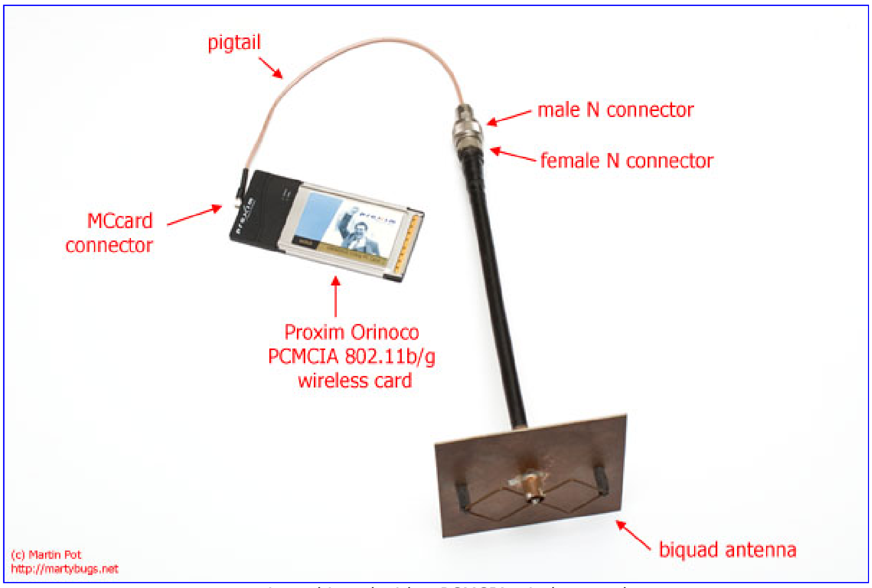
using a biquad with an UltraWAP wireless AP / bridge

Another option is to use a PCMCIA wireless card. The image below shows the components required to connect a biquad antenna to a Proxim/Orinoco 802.11b/g wireless PCMCIA card. Many wireless PCMCIA cards use an MCcard socket, and when a cable is plugged into it, the internal antenna in the card is disabled. An MCcard to male N connector pigtail is required to connect the biquad antenna to this particular card.



using a biquad with a PCMCIA wireless card

The image below shows the biquad antenna connected to the Proxim/Orinoco PCMCIA card.



using a biquad with a PCMCIA wireless card

Credits

All photos are copyright Martin.

last updated 22 Oct 2013

ON6MU's

Allmode 5-band RF Power Amplifier

for the HF 80, 40, 30, 20 and 17 meterband

RE-PA30HF5B

By Guy, de ON6MU
rev1.1b oct/09
Prototype

About the 5-band HF amplifier RE-PA30HF5B (prototype)

This project uses a widely available IRF510 MOSFET. This N-Channel enhancement mode silicon gate power field effect transistor is an advanced power MOSFET designed, tested, and guaranteed to withstand a specified level of energy in the breakdown avalanche mode of operation.
MOSFETs operate very differently from bipolar transistors. MOSFETs are voltage-controlled devices and exhibit a very high input impedance at dc, whereas bipolar transistors are current-controlled devices and have a relatively low input impedance. Biasing a MOSFET for linear operation only requires applying a fixed voltage to its gate via a resistor.
The built-in self-regulating actions prevent MOSFETs from being affected by thermal runaway. MOSFETs do not require negative feedback to suppress low-frequency gain as is often required with bipolar RF transistors.
I chose the IRF510 because lots of hams use 'em and they're cheap. But they perform a bit less when it comes to constant gain and/or power output across a wide range of frequency bands. I wasn't especially concerned with that, and the advantages outweigh the contra's, so I went with that MOSFET.

Rather then using a 1:4 toroid (which is excellent) to match Q1 impedance to 50 Ohms, I have applied the "old school" radio valve coupling; impedance matching circuitry between the output and the antenna using a L-filter...Why? FET devices are more closely related to vacuum tubes than are bipolar transistors (and because I do like to do things my way HI). Both vacuum tubes and the FET are controlled by the voltage level of the input rather then the input current. They have three basic terminals, the gate, the source and the drain. These are related and can be compared to the vacuum tube terminals. The ralationship between the two doesn't stop here...The two most important relationships are called the transconductance and output. An advantage of MOSFET devices is that they do not have gate leakage current and MOSFETs do not need input and reverse transconductance.

The amplifier is made to be driven by transmitters in the ½ to 2 watt range. Built-in to the power amplifier is a sensitive (Q2) T-R relay which will switch the unit in and out of the
antenna line. When in receive, the amplifier is bypassed and the antenna feeds directly to the input jack, when you go to transmit, the T-R circuit detects the transmit RF power and automatically switches the power amplifier into the circuit and amplifies the applied RF power. If you decide to run "barefoot" turning off the AMP it will disable the amplifier and your QRP
transmitter will feed directly through the amplifier without any amplification.
Power is supplied by any 14 to 25 volt (or 2 x 12v battery) DC source with a current draw of 1 to 3 amps depending upon RF power output.

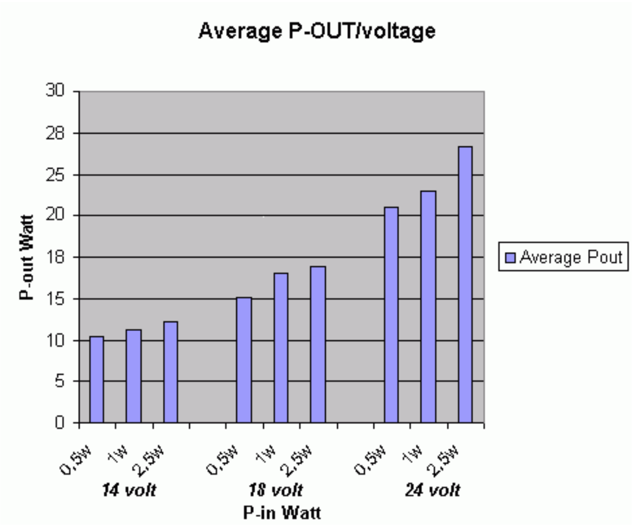
The linear amplifier can be used with QRP SSB/CW/FM/AM/PSK transmitters on any of the amateur bands between 80m...17 meters.

The completed amplifier will reward the builder with a clean, more powerful output signal for a QRP rig when radio conditions become marginal.

Band selection
Switching beween bands is done manually using a rotary switch.
You can build the amplifier for only one band or a combination of any other of the five available bands.

Drive
The input drive can be anything from 0.4watt to 2 watt max, which will be amplified to +/- 25 watt. The output varies on the drive power and the applied voltage.

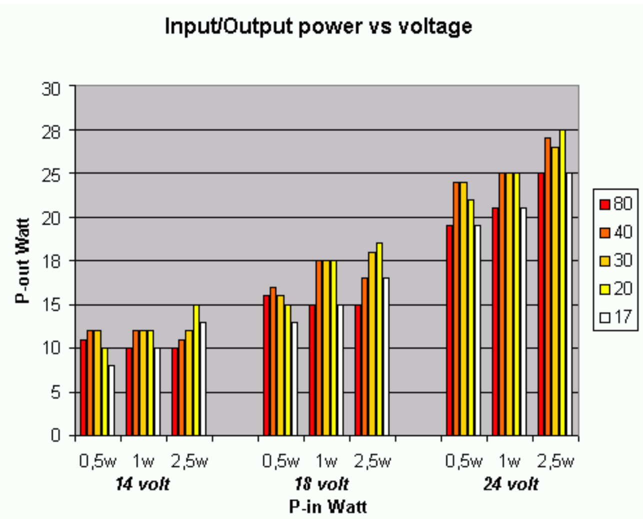
Graph 1: Average Output Power vs voltage



<u>Power</u>
The power output is not perfectly linear to the input frequency/band. The impedance 50 Ohms match could be solved by using a 1:4 toroid, or as I like to use, the "old school" radio valve coupling; impedance matching circuitry between the output and the antenna using a L-filter...And, the IRF510 isn't perfect (*note: there are also low grade versions of the Mosfet out there which can lower the output power and influence the quality of the signal/waveform*).
The N-channel mosfet has an input capacitance thats a bit on the high side and the output capacitance that varies with the cross over frequency. It can be a slight problem when it comes to constant gain and/or power output across a wide range of frequency bands. I wasn't especially concerned with that so I went with this MOSFET anyway. Of course the main issue was the simple design to be able to use one band or even up to five bands if wanted, which always has some compromise in this type of design. This means that there is some fluctuation of the output power par band.

When driven between the optimal range of +/- 1.5 watt the amplifier more then capable to deliver 25 watts +/- 10%. Output power for AM should be set to +/- 50% of max.
Although the design allows you to work in a varied range of voltages, the maximum output is only guarenteed @ 24volts.

Graph 2: Input/Output Power vs Voltage



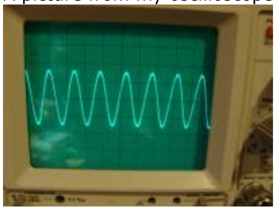
Higher power then 2 watts does not improve linearity as you can see in the above chart.

<u>Bias</u>
The power amplifier require biasing for proper RF performance. BIAS has be applied to Q1 to have clean proper and correct SSB modulation using this amplifier. Set P1 so that +/- 100 mA current flows through Q1.

<u>Modulation modes</u>
If proper BIAS to Q1 is applied, you can amplify any type of modulated wave.
Output power for AM should be set to +/- 50% of max.

<u>Filter</u>
RF purity and harmonic suppression is done here. Also allowing the FET to be coupled to the antenna system through antenna impedance matching circuitry (C16...C20, L2, C21...C25, C26, L4,C27). Care is taken at this stage so that no harmonic frequency is generated which will cause interference in adjacent band/harmonics on other bands. This 4-element L-type narrow band-pass filter circuit and a 3 element low-pass Butterworth PI filter for the desired frequency removes out any remaining harmonic signals very efficiently.

A picture from my oscilloscope:



<u>RF-sensing</u>
The basic principle of RF-sensing using a relay is clearly drawn in the schematic and pretty much self explaining.
Tip: I would like to recommend to add a mini-switch between C31 and GND if you plan to use it for CW. The on-time is to long for CW.

<u>Input Attenuator</u>
I made provisions to include an RF attenuator consisting out a Pi network of R2, R3/R4, R5 which gives a Forward Attenuation of 3.63 dB and a Input Return Loss of 23.23dB. There are numerous of reasons why I implemented it in this design. It improves overall linearity, achieves some "protection" and enhances stability of the drive input (being a transmitter, transceiver) and Q2 gate.

<u>Cooling/heatsink</u>
Q2 needs to be mounted isolated from the heat sink. Use proper thermal grease and isolator.
I used an old P3 heat sink, which work just fine.

I mounted a Pentium 3 heatsink on the back of the alu-casing. A square space is cut out of the back of the alu-box to allow Q2 to be screwed onto the heatsink. The heatsink is firmly mounted on the back of the chassis with thermal grease allowing the chassis as extra cooling surface.

<u>Construction considerations</u>
HAMs that are experienced in constructing RF projects will know a number of possibilities to create a good RF design.
Because I started from scratch and still was in experimental/design stages I have placed the capacitors/trimmers of each band directly around the switch, including the 80m coil L3. This works perfectly when short connections are used. You can however solder them directly to the PCB.

I mounted a Pentium 3 heatsink on the back of the alu-casing. A square space is cut out of the back of the alu-box to allow Q2 to be screwed onto the heatsink. The heatsink is firmly mounted on the back of the chassis with thermal grease allowing the chassis as extra cooling surface.

One thing I would like to bring to your attention...that are the trimmers that are used to tune each band (Ct1...Ct5). Do <u>not</u> use plastic trimmers, they will melt and perhaps burn through causing shortening and possible failure of Q2 and who knows what else. Please use air- or ceramic based trimmers.
If you do not have them, then the only way tweaking the amplifier by trial-and-error, hence adding C parallel to C16...C20 respectively.
These were my C's: C16=470, C17=340, C18=200, C19=80, C20=43pF

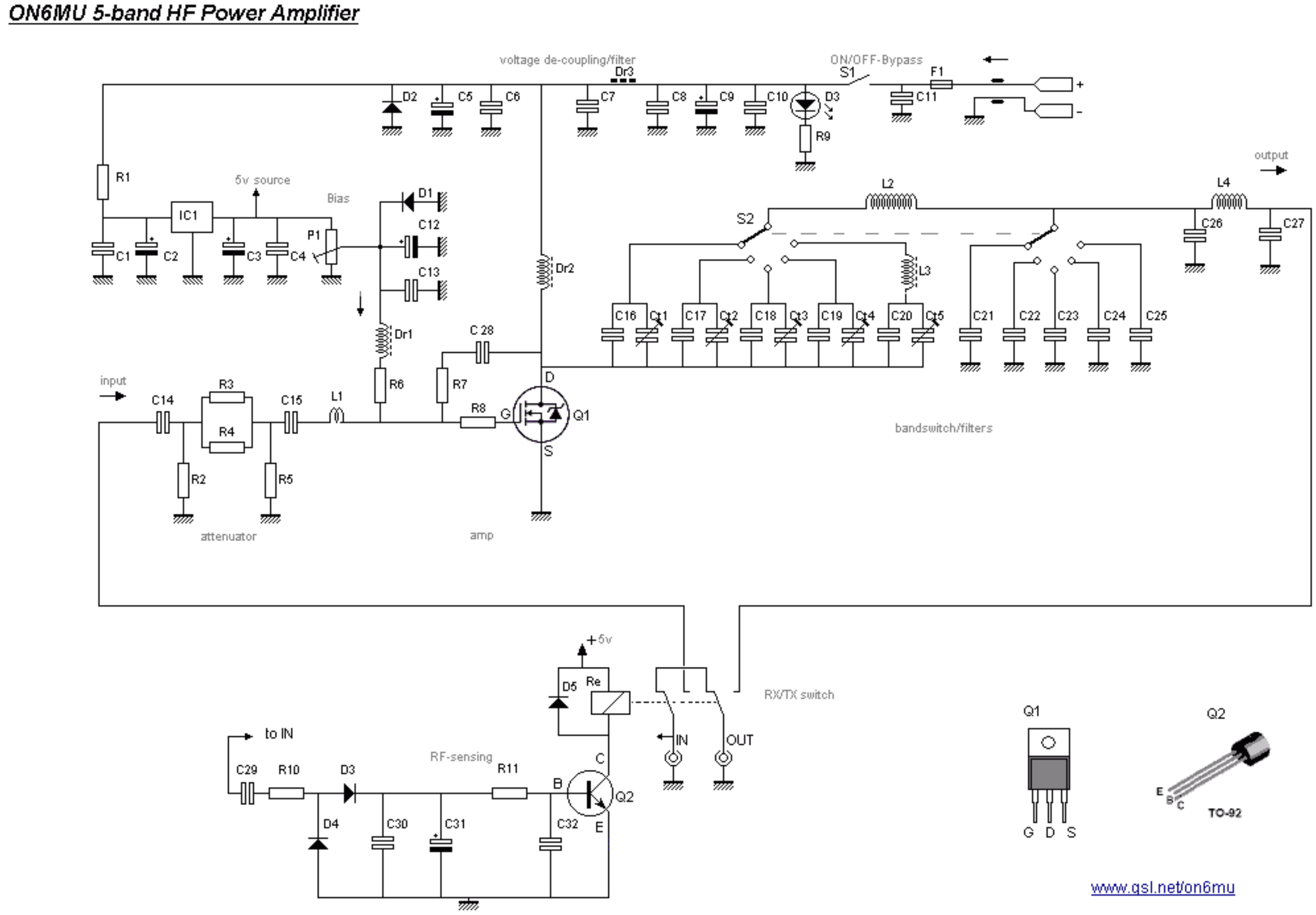
Use a choke (or a snap-on ferrite bead) at the point where the Vcc wires leave the alu-box.

Use small 50 Ohm coax between the in- and output of the PCB connections to the SO-239 connectors.

<u>Enclosure Recommendations</u>
To accomplish RF shielding the whole circuit needs to be mounted in an all-metal/aluminum case.

<u>Grounding</u>
To prevent ground loops, spurious oscillations etc. please take attention to:
- decouple the PCB in the chassis (housing)
- all connections and wire leads should be made as short as possible
- a proper PCB layout with enough ground surface ensuring normal ground paths
- the source of Q2 (IRF510) should also be grounded to the chassis as close as possible

-



Specifications RE-PA30HF5B

- Allmode: AM/FM/CW/SSB/FSK
- Bands: 80m, 40m, 30m, 20m, 17m (or to be used for one separate band if you desire)
- Average output RF power: +/- 25W SSB PEP @ 24v , 13 watt SSB @ 13.8v
- Works great with Yaesu FT-817, Ramsey QRP rigs or any other 1-2 watt transmitters
  Input power drive: 0.4...2.5watt max (ideal 1...2watt)
- All modulation modes
- Efficient band-pass type harmonic L-filter + lowpass Butterworth PI filter
- Usable voltages: Vcc 13.8 - 25 volts
- Average current I: +/- 2.5A @ 24 v at full load
- Built-in T/R relay automatically switches between receive and transmit
- VSWR overload resistant (short period of time, not unlimited)
- Multistage band pass and low pass filter for a clean signal
- Manual band switching (if build for more then one band)


The 5-band HF power amplifier "insides"

The MOSfet 5-band HF Amplifier settings

Needlessly to say, but I will say it anyway, before testing anything please be sure to double check every connection. The project should be finished HIHI.
Connect a proper dummy load and a power meter to the output of the amp. Also put a Ampere meter in series with the Vcc, allowing monitoring of the current during the setup.
Set all trimmers (Ct1...Ct5) half way (in medium setting).
Set P1 to the ground (zero ohms).

Now gently increase the voltage to the amplifier while checking the current till you reach 18 volts. The only current you should see is a the liddle idle current of Q1 (a few milli amps and a a few mA of LED D3 if connected). We do not need the full 24 volts during the tuning/setting stages.

Now gently turn P1 till you get approx. 100 mA.

So far so good? Now we need to check if the (Q2) RF-sensing circuit is working properly (*Although I would like to recommend to test this before anything, rather then building the entire project and test it. Or at least before mounting the PCB in the alu-box, and without Q2 soldered. The RF-sensing ON-time can vary according to the relay used)*.
Connect your transceiver (or other drive) to the input, and set it to the lowest power rating of +/- 0.5watt and set your transceiver to 14.100Mc in CW/FM.
Be sure the dummy load is still at the output of the amp and the bandswitch is also set to 20m band.
Key your transceiver and if all goes well the relay (Re) should power up and you should see the current rise and your power meter should already show an amplification of the RF input power.

All working as planned? Excellent! Now we need to tune the filter-unit by setting the Ct's according to each band.
Set the drive power (your transceiver) to +/- 1...2.5 watts
Turn the band switch (S2) to 80m, as we start with the lowest band and work are way up from there. Also set your transceiver to the middle of the (each) band segment.
Carefully turn Ct5 till you get maximum output power (whilest checking the input SWR on your transceiver/SWR meter).
Current should be around 1.8...2 Amp +/- max (depending on the voltage and input power).
Next is to repeat the above for each band and setting the Ct capacitor trimmer(s) according to each band respectively.

After the filter is tuned in respect to each band you can increase the voltage to 24 volts. Then check everything again, band by band. Could be that you notice a slight difference in the peak output power, do to the capacity of the switch and the filter components. Just re-tune (if needed) each trimmer (Ct1...Ct5) for each band respectively.
The maximum current of the amplifier should never exceed 3 amps.

RF-sensing considerations
The basic principle of RF-sensing using a relay is clearly drawn in the schematic and pretty much self explaining. Q2 (BC338, 2N2222) will conduct when RF energy is applied at the input of the amp (via R10, C29, D3, D4, C30 biasing the base of Q2) hence powering up a RF capable relay. This relay switches between RX and TX with amp. When no Vcc is applied to our amplifier (and so Q2 too) no amplification is done bypassing the amplification. The input is simply re-directed directly to the output (as if your transceiver is connected without an amp). The RF sensing circuit is sensitive enough to react on .5 watt easily.
To allow the amplifier in SSB-modulation some extended PTT time-on the RF-sensing unit (Q2->relay) has to be increased. C31 adds the needed "breathing" time. In FM/CW/AM/FSK modes a carrier is present and extended PTT time-on of the amplifier isn't needed, hence can be short.
Important: Everything will be within specs if you use RY5W relay, but timing delay (the "breathing time") can vary on the type of relay used (Ohms resistance value of the relay coil), hence experimentation of C31 is needed.

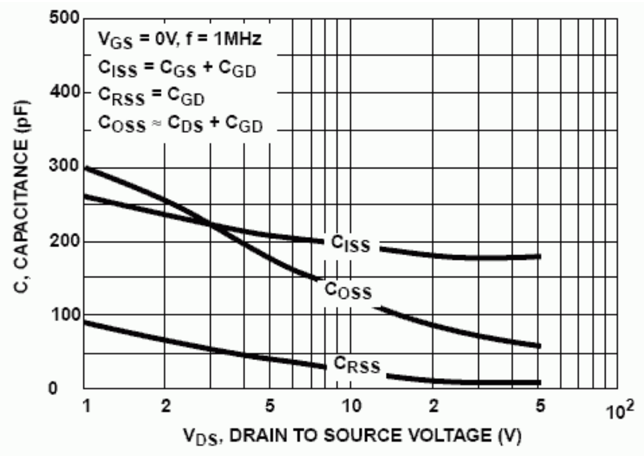
Although this example of RF-sensing isn't the Worlds most best sollution, it is pretty easy for beginners and effective though. Better would be to drive Q2 from your transceiver (amp drive) as this will switch the amp at the very moment of PTT.
Tip: I would like to recommend to add a mini-switch between C31 and GND if you plan to use it for CW. The delay is too long for CW.

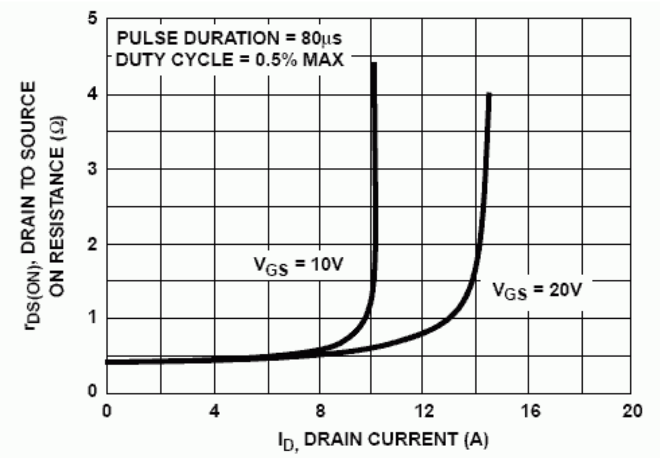
Note:
Always use a dummy load for testing and adjusting the amplifier!!!
Remember that this is a prototype.

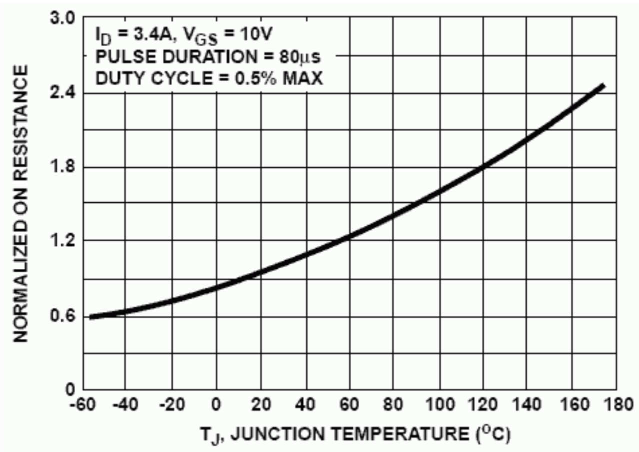
Rev1.1 oct/09

In the schematic D1 was shown in reversed state, hence could not set Bias correctly: fixed
Shunt Dr2 total turns was wrongly specified. Should be 20 turns instead of 35: fixed

MOSFET specs:



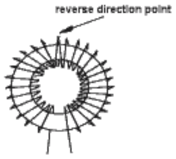




Coils

All we need to do now is make a few remaining coils that have to be handmade - for that "old-world craftsmanship" touch!
The wire used for the coils are enameled wire (stripped from any AC transformer).

Dr1: you need a ferrite core of 3mm diameter and about 5...8mm long. You wind 30 turns up and down the core, with no spacing. Wire used is 0.4mm enameled wire.



Dr2: Shunt made out of a small yellow/white toroid of +/- 13mm diamter (like those often found in PC switched power spupplies etc.). It has about 2 times 25 turns of 0.8mm enameled wire. Turn 25 turns closely together till you reach half way the toroid. Then reverse direction and make another 25 turns till you reach the end. This shunt is not too critical, so a few turns more or less will not cause any problem, but do not leave any space between the turns. Note: Also the toroid core type isn't ciritical, almost any type will do (*you can use a 'normal' wound toroid with no reverse direction if prefered, but the linearity may suffer a little.*).

Dr3: a ferrite bead where you turn a few times a 0.6 mm wire through.

L1: 2 turns, no spacing, 5 mm inside diameter, 0.6mm gauge enameled wire

L2: 22 turns close together of 1.2mm enameled wire. Inside diameter is 9.5 mm and 26.5 mm long

L3: You need a ferrite core 14mm long (I broke a piece of a ferrite core like found in those old AM-radio's) and wind 11 turns close together of 1.2 mm enameled wire over the core. Inside diameter of the core is 9.5mm

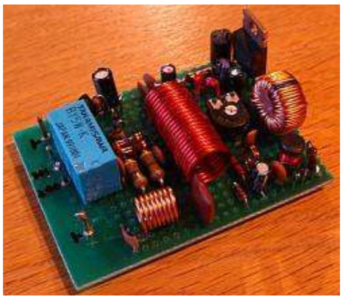
L4: 8 turns close together of 1.2 mm enameled wire. Inside diameter is 6.5mm and is 9.6mm long

Tip: remember to vernish or glue-fix the coils to prevent FM'ing do to vibrations

Parts list 5-band HF power amplifier

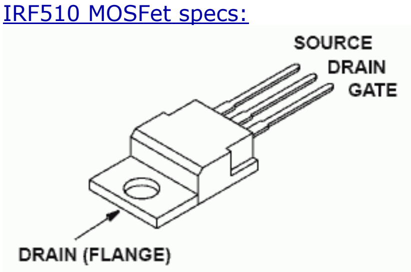
- Q1: N-Channel IRF510 MOSFET
  (with proper heatsink isolated from the mosfet)
- Q2: NPN BC338/337, 2N2222...
- IC1 = 78H05 or 78L05
- C1: 100n
- C2: 1uF/50v
- C3: 1uF/16v
- C4: 100n
- C5: 2.2uF/50v
- C6: 100n
- C7: 4n7
- C8: 10n
- C9: 47uF
- C10: 100n
- C11: 47n
- C12: 1uF/16v
- C13: 68n
- C14: 100n
- C15: 100n
- C16: 39, ceramic 200v
- C17: 68, ceramic 200v
- C18: 180, ceramic 200v
- C19: 2 x 150pF parallel (or 330), ceramic 200v
- C20: 2 x 220pF parallel (or 470), ceramic 200v
- C21: 100, ceramic 200v
- C22: 220, ceramic 200v
- C23: 220, ceramic 200v
- C24: 470, ceramic 200v
- C25: 1200, ceramic 200v

- C26: 220, ceramic 200v
- C27: 100, ceramic 200v
- C28: 2n2
- C29: 470p
- C30: 47n
- C31: 68uF/tantalum 16v (determines the ON-time for RF-sensing)
- C32: 150n
- R1: 47 1/2w
- R2: 390 1/2w
- R3: 47 1/2w
- R4: 47 1/2w
- R5: 390 1/2w
- R6: 1k
- R7: 1k
- R8: 10 1/2w
- R9: 18k
- R10: 1k
- R11: 1k
- P1: 5k potentiometer (BIAS setting Q2)
- D1, D3, D4: 1N4148
- D2, D5: 1N14001
- S1: Toggle switch (ON/OFF-Bypass)
- S2: 5-position quality switch (if possible silver plated)
- Ct1: 20pF ceramic or air-spaced trimmer
- Ct2: 30pF ceramic or air-spaced trimmer
- Ct3: 60pF ceramic or air-spaced trimmer
- Ct4: 60pF ceramic or air-spaced trimmer
- Ct5: 100pF ceramic or air-spaced trimmer
- 2 x SO239 connectors
- Re: RY5W-K relay
- F1 = 4 amp
- Alu-box
- Heatsink + thermal grease
- Dr1: ferrite core 3mm diameter, 5...8mm long. 30 turns, 0.4mm wire (+/- 4.7uH)
- Dr2: yellow/white toroid of +/- 13mm diamter, 2 x 20 turns of 0.8mm wire
  Note: the type of toroid isn't too critical, so almost any core will do. It could be that some experimentation is needed to find the optimum value.
- Dr3: a ferrite bead with 4 turns of 0.6 mm wire
- L1: 29nH; 2 turns, no spacing, 5 mm inside diameter, 0.6mm wire
- L2: 1.4uH; 22 turns close together, 1.2mm enameled wire. Inside diameter is 9.5 mm
- L3: 3.8uH; ferrite core 14mm long, 11 turns close together, 1.2 mm enameled wire. Inside diameter 9.5mm
- L4: 410nH; 8 turns close together of 1.2 mm enameled wire. Inside diameter is 6.5mm



Note: the caps C16 till C27 may have higher voltage specifications, but no less then 150v.

IRF510 MOSFet specs:



Drain to Source Voltage	VDS: 100 V
Drain to Gate Voltage (RGS = 20kW)	VDGR: 100 V
Continuous Drain Current	ID: 5.6 A
TC = 100oC	ID: 4 A
Pulsed Drain Current	IDM: 20 A
Gate to Source Voltage	VGS: ±20 V
Maximum Power Dissipation	PD: 43 W
Linear Derating Factor	0.29 W/C°
Single Pulse Avalanche Energy Rating	EAS: 19 mJ
Operating and Storage Temperature Range	TJ, TSTG: -55 to 175 C°
Input Capacitance	f = 1.0MHz - 135 - pF
Output Capacitance	COSS - 80 - pF
Reverse-Transfer Capacitance	CRSS - 20 - pF
Internal Drain Inductance LD Measured From the Contact Screw On Tab To Center of Die	3.5nH
Pulse Source to Drain Current	ISDM - - 20 A
Source to Drain Diode Voltage VSD TJ = 25C°, ISD = 5.6A, VGS = 0V.	2.5 V

LT-Spice simulations

here

Pictures of users who build the project

This is how John SV1ONK did it:




He made it for the 20-meter band.

Thanks John!

This how Konstantinos SV1ONW made it:



Thanks Konstantinos!

Little note on Antenna's

It's important to use a correct designed antenna according to band you would like to operate, or at least use a good antenna tuner to match the antenna (protecting your transmitter and proventing harmonics/interference...).

A resonant antenna is an absolute requirement for QRP operation, and an amplifier is not a "band-aid" for a poor antenna system!
We cannot expect good results from low levels of RF output if the power gets wasted in lousy coax, corroded connections, or poor antennas. Several examples can be found on my website and all across the Web. A dipole is always a good alternative (total length = 150 / freq - 5%).

Another related project:
15 & 17 meter band transistor 10 watt amplifier

Remember that transmitting and/or using an power levels higher then your local license permit is illegal without a valid radioamateur license!

ON6MU
Home

ON6MU

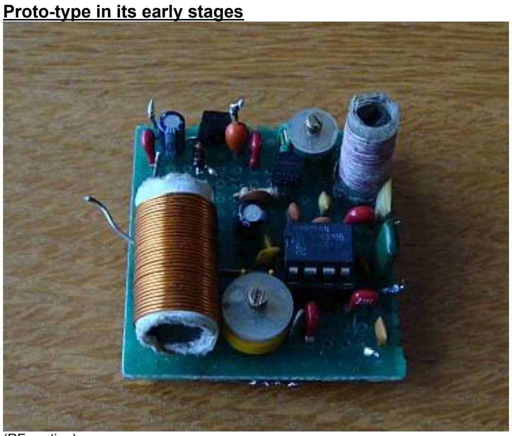
RX1HF80: 80m SSB/CW/AM Receiver

prototype
most recent update 11th of January 2012

About RX1HF80

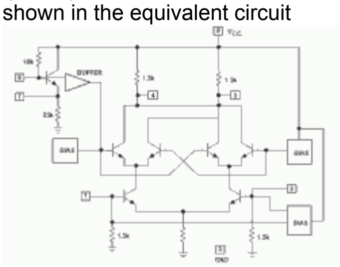
I wanted to make a compact battery powered 80m band SSB receiver. Not only that, it should also be sensitive receiver and a simple design. I had experience with the SA612 double-balanced mixer (8 pin IC) (check out my Magic-band converter and my DRM converter), but I did'nt want to make a converter. It really had to be stand-alone little receiver. After a whole lot of time experimenting and burning up a few components in the progress I finally had a proto-type. It is not too complicated, but some experiance to build it yourself will be needed.
Also, my proto-type was build upon a experiment copper square PCB. I used that so I could change things easier while I was desinging/making it. I have to stress out that it wont work properly using such a experminal printboard!

Proto-type in its early stages


(RF section)

I got it to work by keeping it small, using very short connections and made the ground connections large so no RF loops would occur. The dead-bug methode could probably work too although I did not test it. I really need somebody who can make a PCB for the RX1HF80!! Anybody out there? Anyway, it can be done using a cheap circuit board **IF** you take real good care of the connections and ground paths hence honoring the principles on building (V)HF projects. And keep the audio stage and HF part separate. Of course when we can find a PCB designer for this project all sections of the receiver could be on the same PCB.

SA612 Mixer
The heart of the receiver is the SA612A is a low-power monolithic double-balanced mixer with on-board oscillator and voltage regulator. It is intended for low cost, low power communication systems with signal frequencies to 500MHz and local oscillator frequencies as high as 200MHz. The mixer is a “Gilbert cell” multiplier configuration which provides gain of 14dB or more at 45MHz. The oscillator is configured for tuned tank operation. The low power consumption makes the SA612A excellent for battery operated equipment. Also you'll benefit from very low radiated energy levels within. The SA612A is capable of receiving -119dBm signals with a 12dB S/N ratio. Third-order intercept is typically -15dBm (that’s approximately +5dBm output intercept because of the RF gain). It also has a temperature compensated bias network as shown in the equivalent circuit



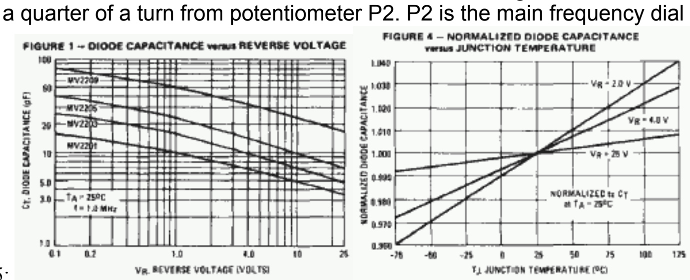
It works pretty well in this receiver, but in practice it shows some intermodulation when signals are strong. That is why I added a bandpass front-end filter. It greatly reduced the intermodulation.

What kind of radio is it?
You can listen to SSB signals (actually like the SA612 is used here it demodulates LSB and USB more like a DSB). It does not separate LSB and USB. CW can also be received as can DSB. AM is tuned like with any SSB receiver to the dominant frequency peak meaning the middle of the AM signal (zero-beat). Anyway, because I wanted to keep the simplicity of the project I opted for direct conversion. Direct conversion means that you process the incoming RF signal at its frequency without down converting it to an IF (Intermediate Frequency) and then processing the IF frequency. Direct conversion single sideband receivers are of interest because they are less subject to spurious responses than the conventional superheterodyne, do not entail the use of high-gain narrowband amplifiers with high centre frequency, and lend themselves better to integration in monolithic form.
The most important feature of a direct-conversion SSB transceiver is that there are no complicated conversions nor image frequencies to be filtered out. However, the RF section of a direct-conversion SSB transceiver requires simple LC filters to attenuate far-away spurious responses like harmonics and subharmonics.
This direct-conversion SSB transceiver includes some critical components like precision (1%) resistors en quality capacitors to ensure its stability. Do not dismiss this, it is important.

Design tips
To keep the receiver stable as possible and without frequency drifts you need to use components that has good temperature qualities. I can not emphasize it enough how important this is! Using low quality junkbox components will cause a unstable receiver. I have marked the critical components with an asterisk * .
For * resistors: please use metal film 1%
For * capacitors: please use mika, polystyrene or multilayer ceramic capacitor (*multilayer ceramic capacitor has a many-layered dielectric. These capacitors are small in size, and have good temperature and frequency characteristics*)

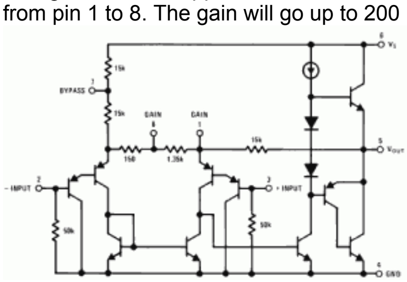
Notes: I got it to work by keeping it small, using very short connections and made the ground connections large so no RF loops would occur. The dead-bug methode could probably work too although I did not test it. I really need somebody who can make a PCB for the RX1HF80!! Anybody out there?
Anyway, it can be done using a cheap circuit board **IF** you take real good care of the connections and ground paths hence honoring the principles on building (V)HF projects. And keep the audio stage and HF part separate.

MV2205 Varactor and tuning
The receiver tunes using a varicap (Capacitance Varactor Diode). If you can not find the MV2205 you can use a BB409 (**see text below*). Anyway, I could use the entire very broad 80m band with both types of varicaps. With other types you probably will need to adjust C17 and C20 and perhaps R1, or R2, or R3 or R4 or a combination. It will come down to get a full 80m band coverage and a proper bandspread. We do not want the entire band in a quarter of a turn from potentiometer P2. P2 is the main frequency dial and P1 allows fine tuning.

MV2205:


BB409 Varactor
I have been experimenting using the popular and easy to find BB409 Varactor Diode. It has a max capacity of 32pF. Comes close to the MV2205, but the lowest capacity is a bit more different hence changing a few components was necessary. Also the temperature coefficient of the diode capacitance is slightly inferior, but it causes no problems. It does the job. So what componenets needs to be changed when using a BB409 instead? You can leave out C17 and replace C20 with a 220pF component. That's it.

Audio
The audio is power by is a black box LM386 audio amplifier. The LM386 has enough gain to drive a small speaker and it designed for use in low voltage consumer applications. Ideal to use in battery fed applications. The gain is set to the max in this project and not only by using a capacitor from pin 1 to 8. The gain will go up to 200 (46 dB) and additional amplification and audio bandwith range with R7 C32.



Set and calibrate
To set and calibrate the RX1HF80 we need minimum:
- a 'real' accurate receiver or transceiver that is capable of receiving 80m SSB
Although most can be done by "ear" It also helps to have a frequency counter and a RF voltage meter.

First we need to tune the Local Oscillator LO (Colpitts) varactor tuned tank circuit C19 & L1. This need to be set to 80m band. With C19 and L1 you can easily tune between 3Mc and 4.5Mc. The SA602/SA612 double-balanced mixer will mix the incoming RF with LO.
Use a frequency counter or your receiver/transceiver and place a wire from the antenna connector in the proximity of the tank circuit. You'll should hear/see your signal on your radio.

Now we need to peak the front-end tank circuit C9 & L3/L2. This needs to be tuned for maximum peak/sensitivity on the 80m band (preferably in the middel of the band). Tuning C9 will probaly do the trick (in some cases moving the core of L2/L3 can achieve further tuning if needed).

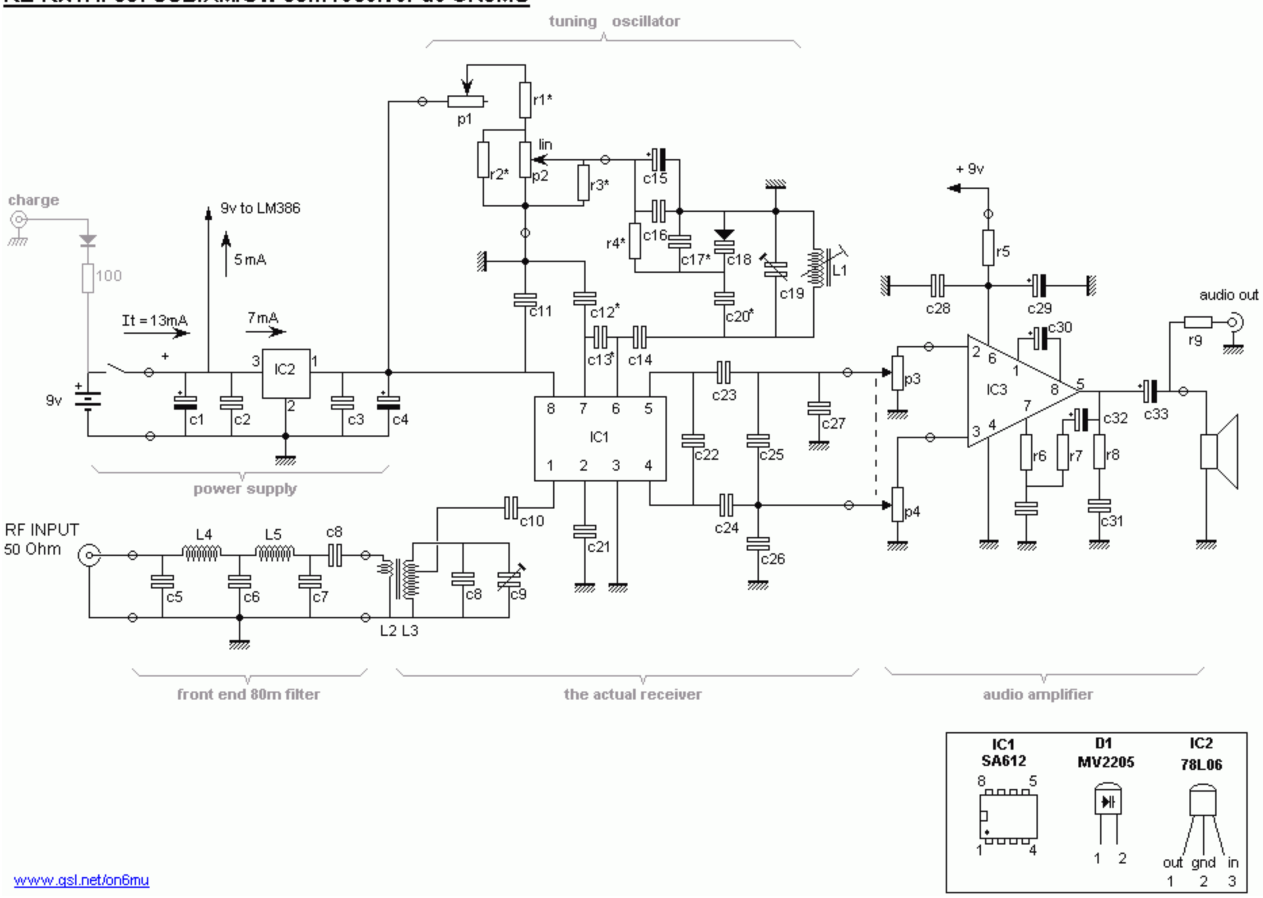
Specs

- Frequency range: 3000 kHz - 4300 KHz (*maximum range with existing components, not the actual tuning range*)
  Note: although the kit can be set to tune anything from 3 to 4.5mc, the design however is made to RX peak in the 80 ham band.
- Tuning range: 400kc+/- typ. 3500...3900Mc
- Varactor tuning
- +/- 1 kc fine tuning (*can be set to other ranges, see text*)
- Modes: USB, LSB, DSB, CW, AM (*I was able to decode sstv, rtty and even psk31*)
- Sensitivity: +/- 0.25uV @ 12dB SINAD
- Mixer noise figure typically lower then 6dB
- Input impedance: 50 Ohm
- AF amp gain 46dB
- AF s/n ratio +/- 80dB
- AF distortion: 0.5% (AV = 20, VS = 6V, RL = 8W, PO =125mW, f = 1kHz)
- Drives a 4...8 Ohm speaker with 500mW output LF power @ 9volts
- U = 8...15 volts when external power operated (9v battery works perfectly too)
- I = 13mA @ 9volts (digital version only 7mA)
- connector for external charging and a connector for LF output (external amp, PC, to decode digimodes as sstv etc.)

Schematics

Analog version

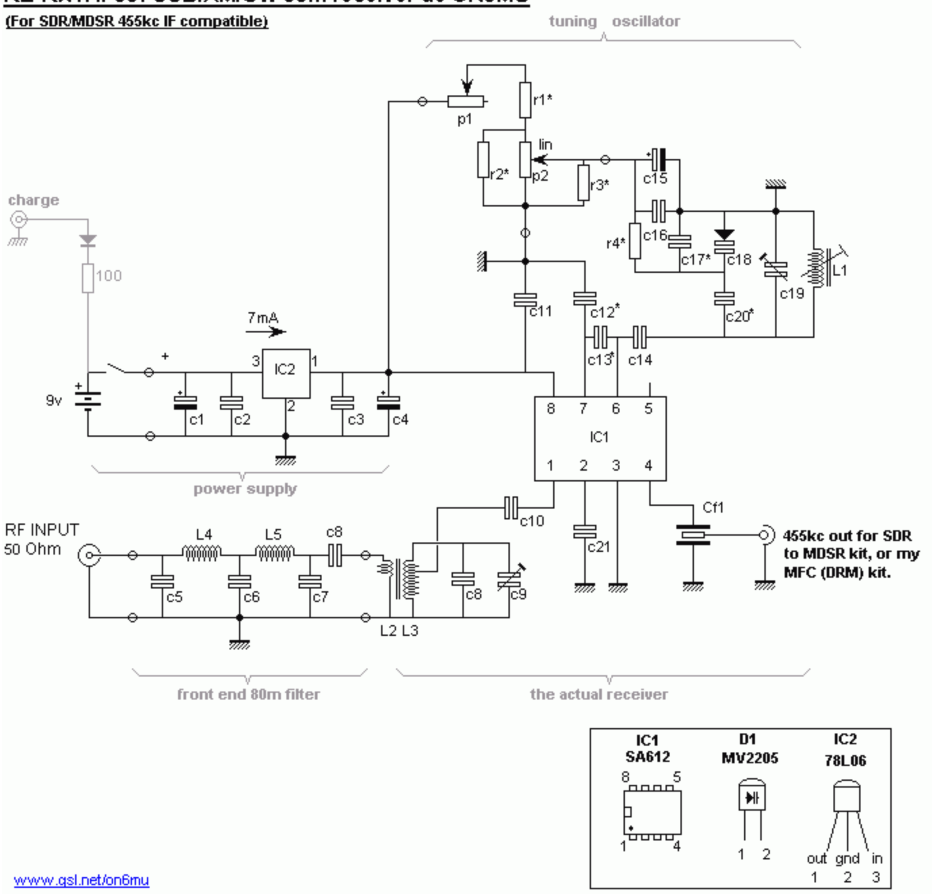
RE-RX1HF80: SSB/AM/CW 80m receiver de ON6MU



Digital version

RE-RX1HF80: SSB/AM/CW 80m receiver de ON6MU

(For SDR/MDSR 455kc IF compatible)



Use the above schematic if you want to use the receiver with MDSR, or with my MFC/DRM demodulator (or with other 455kc

demodulation kits). The LO needs to set slightly differently then in our analog version. It needs to be shifted 455kc up. MDSR software is recommended, however it works fine with other compatible software, like SDRadio, too.

Part list (normal analog version)

- IC1 = SA612AN, SA602, NE602, NE612
- IC2 = 78L06
- IC3 = LM386
- R1 = 1k2 1% metal film (*infuences the bandspread*)
- R2 = 10k 1% metal film (*infuences the bandspread and linearity)*
- R3 = 2k2 1% metal film (*infuences the linearity hence even spread of the frequencies with the pot)*
- R4 = 38k 1% metal film (*this value influences the bias of the varicap hence also the tunable range; LO frequency)*
- R5 = 10
- R6 = 1k5
- R7 = 2k2
- R8 = 10
- R9 = 380
- P1 = 470 (*fine tuning; adjust to aquire other fine tune ranges*)
- P2 = 10k linear (*main tuning)*
- P3 = 22k stereo potentiometer
- C1 = 22uF/25v
- C2 = 100n
- C3 = 100n
- C4 = 10uF/16v tantalum
- C5 = 560
- C6 = 2n2
- C7 = 820p
- C8 = 30p
- C9 = 40p trimmer (yellow)
- C10 = 1000p
- C11 = 1000p
- C12 = 100p (*mika, polystyrene or multilayer ceramic capacitor)*
- C13 = 100p (*mika, polystyrene or multilayer ceramic capacitor)*
- C14 = 1000p
- C15 = 1uF/16v
- C16 = 10n
- C17 = 10p (*mika, polystyrene or multilayer ceramic capacitor)*
- C18 = MV2205 Capacitance Varactor Diode (*others can be used, but the oscillator, spread and tunable range probably needs some attention*)
  Or a BB409 varicap*(*C17 needs to be removed, and C20 needs to be changed to 220pF, please see text for more info).*
- C19 = 30p trimmer
- C20 = 560p (*mika, polystyrene or multilayer ceramic capacitor)*
- C21 = 47n
- C22 = 4n7
- C23 = 100n

- C24 = 100n
- C25 = 6n8
- C26 = 4n7
- C28 = 100n
- C29 = 47uF/25v
- C30 = 10uF/16v
- C31 = 100n
- C32 = 1uF/50v ?
- C33 = 330uF/16v
- L1 = 40 turns, 0.2mm litze (AWG#32), 7mm diameter
- L2 = 3 turns, 0.5mm (AWG#24), 10mm diameter (L2 and L3 are on the same core)
- L3 = 30 turns 0.5 (AWG#24), 10mm diameter, a tap at 10 turns from the top
- L4 & L5 = 35 turns, 0.3mm (AWG#28), 6mm diameter
- Cinch female (audio output)
- SO239 (antenna connector pl259)
- 9v rechargeable battery
- 8 Ohm 0,5w speaker (YD58-2)
- Alu case 120x45x75 (or bigger ;-)
- *All resistors can be 1/4watt or 1/8watt, except R5 that needs to be a 1/4watt type*

Details - Coils

L1: 40 turns, 0.2mm litze (AWG#32), 7mm inside diameter, 13mm long, adjustable ferite core. Core needs to cover the entire length no longer. (L1 = local oscilator resonant @ 80m). *(Ideal would be to shield the LO, but this I could not do because of the small pcb I was forced to use in this prototype)*

L2: 3 turns, 0.5mm (AWG#24), 10mm inside diameter (close to the hot side of the coil, being the top as seen in the schematic)

L3: 30 turns 0.5 (AWG#24), 10mm inside diameter, 17mm long, fits over a ferrite rod (the core can be 'recycled' from an old transistor radio). A tap @ 10 turns.
Important: both L2 and L3 are on the same ferrite core. L2 is wound against the hot side of the coil. The tap on L3 is closest to the hot side. Core needs to cover the entire length no longer.

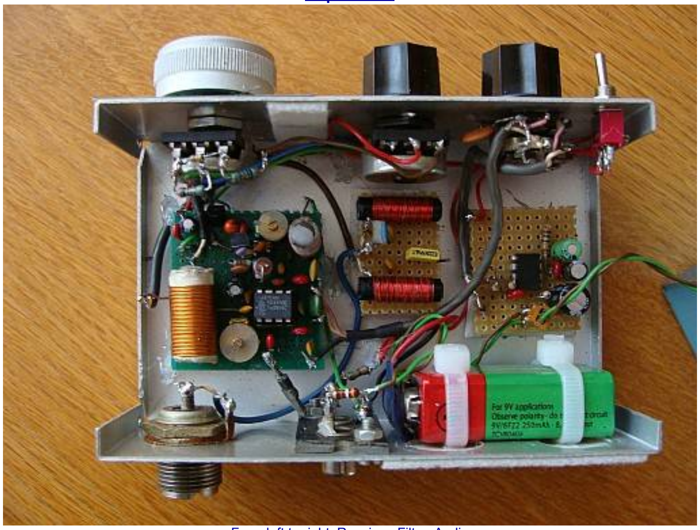
The main resonant tank L2/L3 coil is best wound over a bit of thin cardboard, paper or plastic that snugly fits over the ferrite rod. The coil can then be slid along the rod to adjust the maximal sensitivity if needed (in combination with C9). Mostly the core just covers the entire coil length.
Use this to set the peak the centre frequency the band.

L4 and 5: 35 turns, 0.3mm (AWG#28), 6mm inside diameter, 15mm long. I used a piece of plastic shaft from a potentiometer as "coil holder".

Tips and suggestions:
- use external freq counter to read frequency instead of the analog scale. *(you could then use a 5 or 10 stroke P2 and leave out the fine tuning P1)*
- use a stereo pot (P2) and drive a analog meter to be used as frequency scale readout. Or even a digital meter! *(also here you could then use a 5 or 10 stroke P2 and leave out the fine tuning P1)*

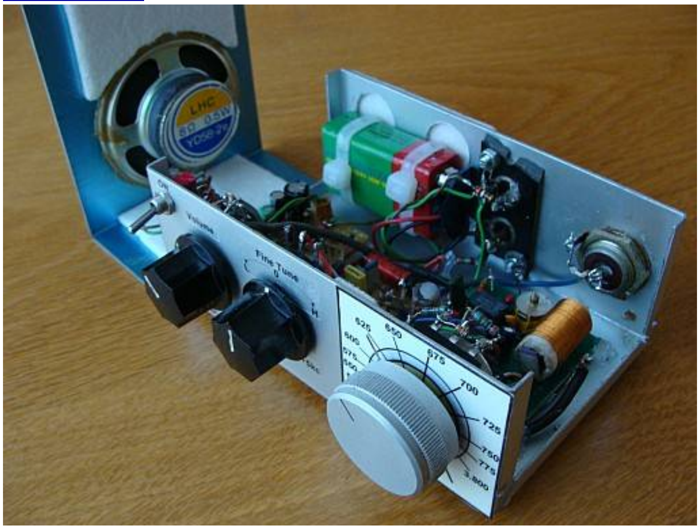
- use a RF-gain ciruit (or use a RF dampening circuit: like a 5K pot that provides gain control by shunting some of the signal to ground).
- an AGC circuit. Could probably be build around the existing LM386 and using that amp to reduce AF gain on strong signals, or an extra amp to function as agc just before the lm386 input....
- when we have found a PCB designer for this project it could easily be build as a portable receiver (handy) and later on design a TX circuit...

top view

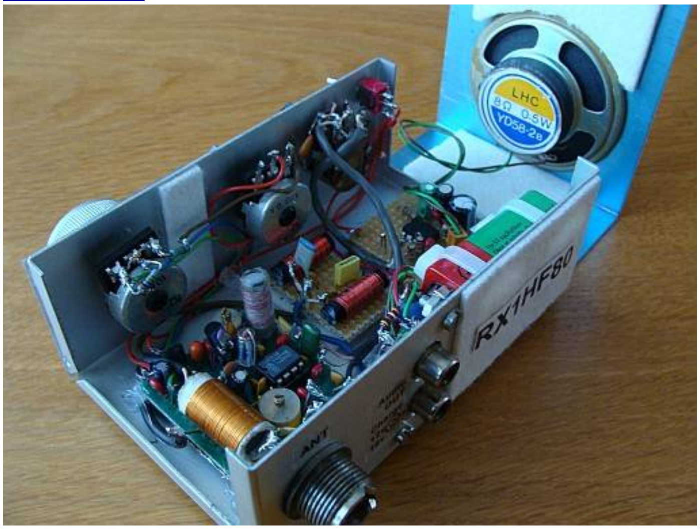


From left to right: Receiver, Filter, Audio

Inside view 1



Inside view 2



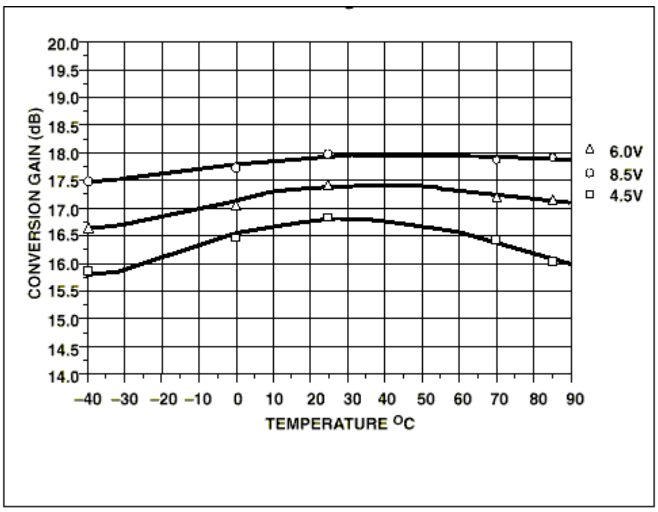


Figure 3 . Conversion Gain vs Supply Voltage

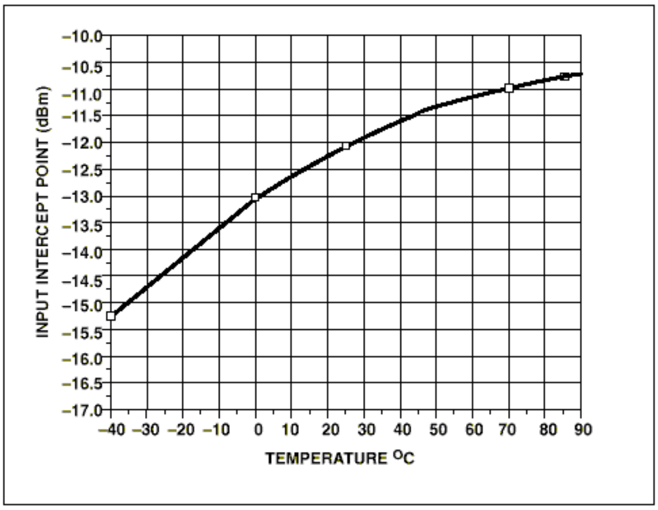


Figure 4 . Third-Order Intercept Point

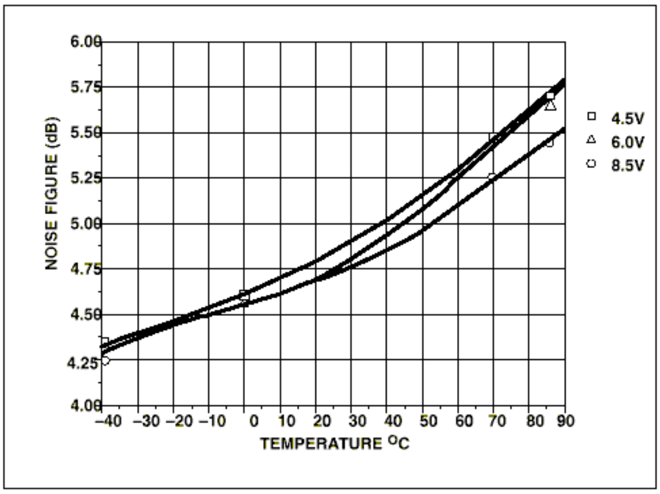


Figure 5. Noise Figure

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Atmospheric electricity

Atmospheric electricity is the study of electrical charges in the Earth's atmosphere (or that of another planet). The movement of charge between the Earth's surface, the atmosphere, and the ionosphere is known as the global atmospheric electrical circuit. Atmospheric electricity is an interdisciplinary topic, involving concepts from electrostatics, atmospheric physics, meteorology and Earth science.[2]

Cloud to ground lightning. Typically, lightning discharges 30,000 amperes, at up to 100 million volts, and emits light, radio waves, x-rays and even gamma rays.[1] Plasma temperatures in lightning can approach 28,000 kelvins.

Thunderstorms act as a giant battery in the atmosphere, charging up the ionosphere to about 400,000 volts with respect to the surface. This sets up an electric field throughout the atmosphere, which decreases with increase in altitude. Atmospheric ions created by cosmic rays and natural radioactivity move in the electric field, so a very small current flows through the atmosphere, even away from thunderstorms. Near the surface of the earth, the magnitude of the field is around 100 V/m.[3]

Atmospheric electricity involves both thunderstorms, which create lightning bolts to rapidly discharge huge amounts of atmospheric charge stored in storm clouds, and the continual electrification of the air due to ionization from cosmic rays and natural radioactivity, which ensure that the atmosphere is never quite neutral.

Contents

History

Description
- Variations
- Near space
- Cosmic radiation
- Earth-Ionosphere cavity
- Thunderstorms and lightning
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- Electrical system grounding

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References and external articles
- Citations and notes
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  - Journals
- Other reading
- Websites

Further reading
External links

History

Sparks drawn from electrical machines and from Leyden jars suggested to the early experimenters, Hauksbee, Newton, Wall, Nollet, and Gray, that lightning was caused by electric discharges. In 1708, Dr. William Wall was one of the first to observe that spark discharges resembled miniature lightning, after observing the sparks from a charged piece of amber.

Benjamin Franklin's experiments showed that electrical phenomena of the atmosphere were not fundamentally different from those produced in the laboratory, by listing many similarities between electricity and lightning. By 1749, Franklin observed lightning to possess almost all the properties observable in electrical machines.

In July 1750, Franklin hypothesized that electricity could be taken from clouds via a tall metal aerial with a sharp point. Before Franklin could carry out his experiment, in 1752 Thomas-François Dalibard erected a 40-foot (12 m) iron rod at Marly-la-Ville, near Paris, drawing sparks from a passing cloud. With ground-insulated aerials, an experimenter could bring a grounded lead with an insulated wax handle close to the aerial, and observe a spark discharge from the aerial to the grounding wire. In May 1752, Dalibard affirmed that Franklin's theory was correct.

Around June 1752, Franklin reportedly performed his famous kite experiment. The kite experiment was repeated by Romas, who drew from a metallic string sparks 9 feet (2.7 m) long, and by Cavallo, who made many important observations on atmospheric electricity. Lemonnier (1752) also reproduced Franklin's experiment with an aerial, but substituted the ground wire with some dust particles (testing attraction). He went on to document the *fair weather condition*, the clear-day electrification of the atmosphere, and its diurnal variation. Beccaria (1775) confirmed Lemonnier's diurnal variation data and determined that the atmosphere's charge polarity was positive in fair weather. Saussure (1779) recorded data relating to a conductor's induced charge in the atmosphere. Saussure's instrument (which contained two small spheres suspended in parallel with two thin wires) was a precursor to the electrometer. Saussure found that the atmospheric electrification under clear weather conditions had an annual variation, and that it also varied with height. In 1785, Coulomb discovered the electrical conductivity of air. His discovery was contrary to the prevailing thought at the time, that the atmospheric gases were insulators (which they are to some extent, or at least not very good conductors when not ionized). Erman (1804) theorized that the Earth was negatively charged, and Peltier (1842) tested and confirmed Erman's idea.

Several researchers contributed to the growing body of knowledge about atmospheric electrical phenomena. Francis Ronalds began observing the potential gradient and air-earth currents around 1810, including making continuous automated recordings.[4] He resumed his research in the 1840s as the inaugural Honorary Director of the Kew Observatory, where the first extended and comprehensive dataset of electrical and associated meteorological parameters was created. He also supplied his equipment to other facilities around the world with the goal of delineating atmospheric electricity on a global scale.[5] Kelvin's new water dropper collector and divided-ring electrometer [6] were introduced at Kew Observatory in the 1860s, and atmospheric electricity remained a speciality of the observatory until its closure. For high-altitude measurements, kites were once used, and weather balloons or aerostats are still used, to lift experimental equipment into the air. Early experimenters even went aloft themselves in hot-air balloons.

Hoffert (1888) identified individual lightning downward strokes using early cameras.[7] Elster and Geitel, who also worked on thermionic emission, proposed a theory to explain thunderstorms' electrical structure (1885) and, later, discovered atmospheric radioactivity (1899) from the existence of positive and negative ions in the atmosphere.[8] Pockels (1897) estimated lightning current intensity by analyzing lightning flashes in basalt (c. 1900)[9] and studying the left-over

magnetic fields caused by lightning.[10] Discoveries about the electrification of the atmosphere via sensitive electrical instruments and ideas on how the Earth's negative charge is maintained were developed mainly in the 20th century, with CTR Wilson playing an important part.[11][12] Current research on atmospheric electricity focuses mainly on lightning, particularly high-energy particles and transient luminous events, and the role of non-thunderstorm electrical processes in weather and climate.

Nikola Tesla and Hermann Plauson investigated the production of energy and power via atmospheric electricity.[13] Tesla also proposed to use the atmospheric electrical circuit to transceive wireless energy over large distances, but no feasible apparatus to extract energy from atmospheric electricity has been built.[14][15]

Description

Atmospheric electricity is always present, and during fine weather away from thunderstorms, the air above the surface of Earth is positively charged, while the Earth's surface charge is negative. It can be understood in terms of a difference of potential between a point of the Earth's surface, and a point somewhere in the air above it. Because the atmospheric electric field is negatively directed in fair weather, the convention is to refer to the potential gradient, which has the opposite sign and is about 100V/m at the surface. There is a weak conduction current of atmospheric ions moving in the atmospheric electric field, about 2 picoAmperes per square metre, and the air is weakly conductive due to the presence of these atmospheric ions.

Variations

Global daily cycles in the atmospheric electric field, with a minimum around 03 UT and peaking roughly 16 hours later, were researched by the Carnegie Institution of Washington in the 20th century. This Carnegie curve[16] variation has been described as "the fundamental electrical heartbeat of the planet".[17]

Even away from thunderstorms, atmospheric electricity can be highly variable, but, generally, the electric field is enhanced in fogs and dust whereas the atmospheric electrical conductivity is diminished.

Near space

The electrosphere layer (from tens of kilometers above the surface of the earth to the ionosphere) has a high electrical conductivity and is essentially at a constant electric potential. The ionosphere is the inner edge of the magnetosphere and is the part of the atmosphere that is ionized by solar radiation. (Photoionization is a physical process in which a photon is incident on an atom, ion or molecule, resulting in the ejection of one or more electrons.)

Cosmic radiation

The Earth, and almost all living things on it, are constantly bombarded by radiation from outer space. This radiation primarily consists of positively charged ions from protons to iron and larger nuclei derived sources outside our solar system. This radiation interacts with atoms in the atmosphere to create an air shower of secondary ionising radiation, including X-rays, muons, protons, alpha particles, pions, and electrons. Ionization from this secondary radiation ensures that the atmosphere is weakly conductive, and that the slight current flow from these ions over the Earth's surface balances the current flow from thunderstorms.[3] Ions have characteristic parameters such as mobility, lifetime, and generation rate that vary with altitude.

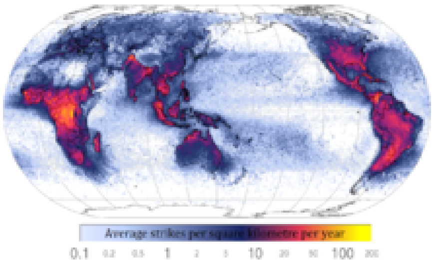
Earth-Ionosphere cavity

The potential difference between the ionosphere and the Earth is maintained by thunderstorms. In the Earth-ionosphere cavity, the electric field and conduction current in the lower atmosphere are primarily controlled by ions.

The Schumann resonance is a set of spectrum peaks in the extremely low frequency (ELF) portion of the Earth's electromagnetic field spectrum. Schumann resonance is due to the space between the surface of the Earth and the conductive ionosphere acting as a waveguide. The limited dimensions of the earth cause this waveguide to act as a resonant cavity for electromagnetic waves. The cavity is naturally excited by energy from lightning strikes.

Thunderstorms and lightning

If the quantity of water that is condensed in and subsequently precipitated from a cloud is known, then the total energy of a thunderstorm can be calculated. In an average thunderstorm, the energy released amounts to about 10,000,000 kilowatt-hours (3.6×10^{13} joule), which is equivalent to a 20-kiloton nuclear warhead. A large, severe thunderstorm might be 10 to 100 times more energetic.



World map showing frequency of lightning strikes, in flashes per km² per year (equal-area projection). Lightning strikes most frequently in the Democratic Republic of the Congo. Combined 1995–2003 data from the Optical Transient Detector and 1998–2003 data from the Lightning Imaging Sensor.

Collisions between ice and soft hail (graupel) inside cumulonimbus clouds causes separation of positive and negative charges within the cloud, essential for the generation of lightning. How lightning initially forms is still a matter of debate: Scientists have studied root causes ranging from atmospheric perturbations (wind, humidity, and atmospheric pressure) to the impact of solar wind and energetic particles.

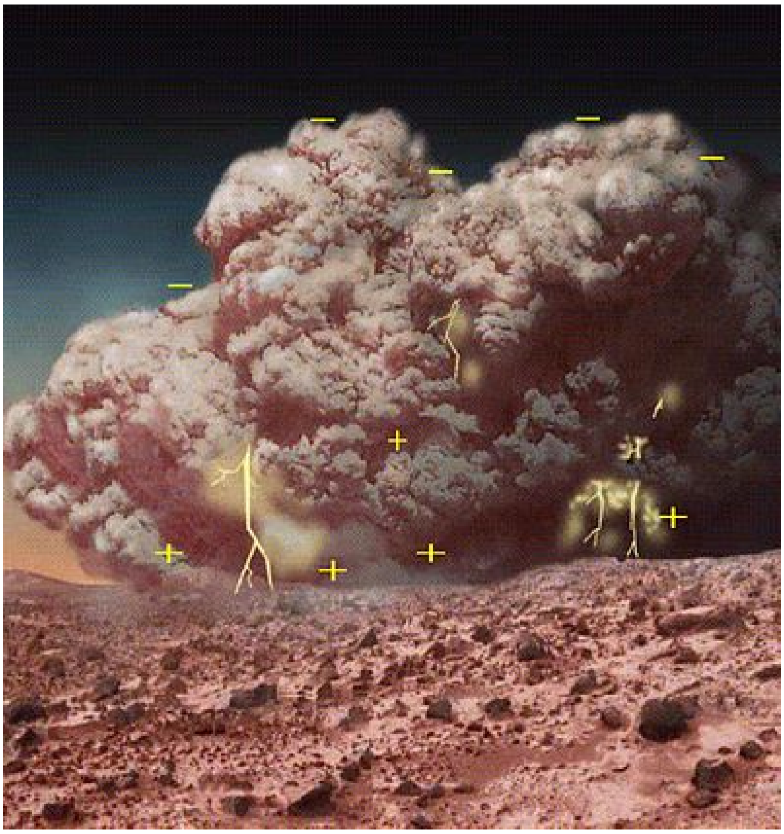
An average bolt of lightning carries a negative electric current of 40 kiloamperes (kA) (although some bolts can be up to 120 kA), and transfers a charge of five coulombs and energy of 500 MJ, or enough energy to power a 100-watt lightbulb for just under two months. The voltage depends on the length of the bolt, with the dielectric breakdown of air being three million volts per meter, and lightning bolts often being several hundred meters long. However, lightning leader development is not a simple matter of dielectric breakdown, and the ambient electric fields required for lightning leader propagation can be a few orders of magnitude less than dielectric breakdown strength. Further, the potential gradient inside a well-developed return-stroke channel is on the order of hundreds of volts per meter or less due to intense channel ionization, resulting in a true power output on the order of megawatts per meter for a vigorous return-stroke current of 100 kA .[9]


Lightning sequence (Duration: 0.32 seconds)

Corona discharges

St. Elmo's Fire is an electrical phenomenon in which luminous plasma is created by a coronal discharge originating from a grounded object. Ball lightning is often erroneously identified as St. Elmo's Fire, whereas they are separate and distinct phenomena.[19] Although referred to as "fire", St. Elmo's Fire is, in fact, plasma, and is observed, usually during a thunderstorm, at the tops of trees, spires or other tall objects, or on the heads of animals, as a brush or star of light.

Corona is caused by the electric field around the object in question ionizing the air molecules, producing a faint glow easily visible in low-light conditions. Approximately 1,000 – 30,000 volts per centimetre is required to induce St. Elmo's Fire; however, this is dependent on the geometry of the object in question. Sharp points tend to require lower voltage levels to produce the same result because electric fields are more concentrated in areas of high curvature, thus discharges are more intense at the end of pointed objects. St. Elmo's Fire and normal sparks both can appear when high electrical voltage affects a gas. St. Elmo's fire is seen during thunderstorms when the ground below the storm is electrically charged, and there is high voltage in the air between the cloud and the ground. The voltage tears apart the air molecules and the gas begins to glow. The nitrogen and oxygen in the Earth's atmosphere causes St. Elmo's Fire to fluoresce with blue or violet light; this is similar to the mechanism that causes neon signs to glow.



A depiction of atmospheric electricity in a Martian dust storm, which has been suggested as a possible explanation for enigmatic chemistry results from Mars (see also Viking lander biological experiments)[18]

Electrical system grounding

Atmospheric charges can cause undesirable, dangerous, and potentially lethal charge potential buildup in suspended electric wire power distribution systems. Bare wires suspended in the air spanning many kilometers and isolated from the ground can collect very large stored capacitance at high voltage static charge potentials, even when there is no thunderstorm or lightning occurring. This charge potential will seek to discharge itself through the path of least insulation, which can occur when a person reaches out to activate a power switch or to use an electric device.

To dissipate atmospheric charge buildup, one side of the electrical distribution system is connected to the earth at many points throughout the distribution system, as often as on every support pole. The one earth-connected wire is commonly referred to as the "protective earth", and provides path for the charge potential to dissipate without causing damage, and provides redundancy in case any one of the ground paths is poor due to corrosion or poor ground conductivity. The additional electric grounding wire that carries no power serves a secondary role, providing a high-current short-circuit path to rapidly blow fuses and render a damaged device safe, rather than have an ungrounded device with damaged insulation become "electrically live" via the grid power supply, and hazardous to touch.

Each transformer in an alternating current distribution grid segments the grounding system into a new separate circuit loop. These separate grids must also be grounded on one side to prevent charge buildup within them relative to the rest of the system, and which could cause damage from charge potentials discharging across the transformer coils to the other grounded side of the distribution network.

See also

General

Geophysics, Atmospheric sciences, Atmospheric physics, Atmospheric dynamics, Journal of Geophysical Research, Earth system model, Atmospheric chemistry, Ionosphere, Air quality, Lightning rocket

Electromagnetism

Earth's magnetic field, Sprites and lightning, Whistler (radio), Telluric currents, relaxation time, electrode effect, potential gradient

Other

Charles Chree Medal, Electrodynamic tethers, Solar radiation

People

Charles Chree, Nikola Tesla, Hermann Plauson, John Alan Chalmers, Joseph Dwyer, Giles Harrison, Michael Rycroft, Charles Thomson Rees Wilson

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Other reading

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External links

- Electric Current through the Atmosphere (http://hypertextbook.com/facts/2006/TerryMathew.shtml)
- The Global Circuit (http://globalcircuit.phys.uh.edu/), phys.uh.edu
- Soaking in atmospheric electricity (https://web.archive.org/web/20080317074712/http://science.nasa.gov/newhome/headlines/essd15jun99_1.htm) 'Fair weather' measurements important to understanding thunderstorms. science.nasa.gov
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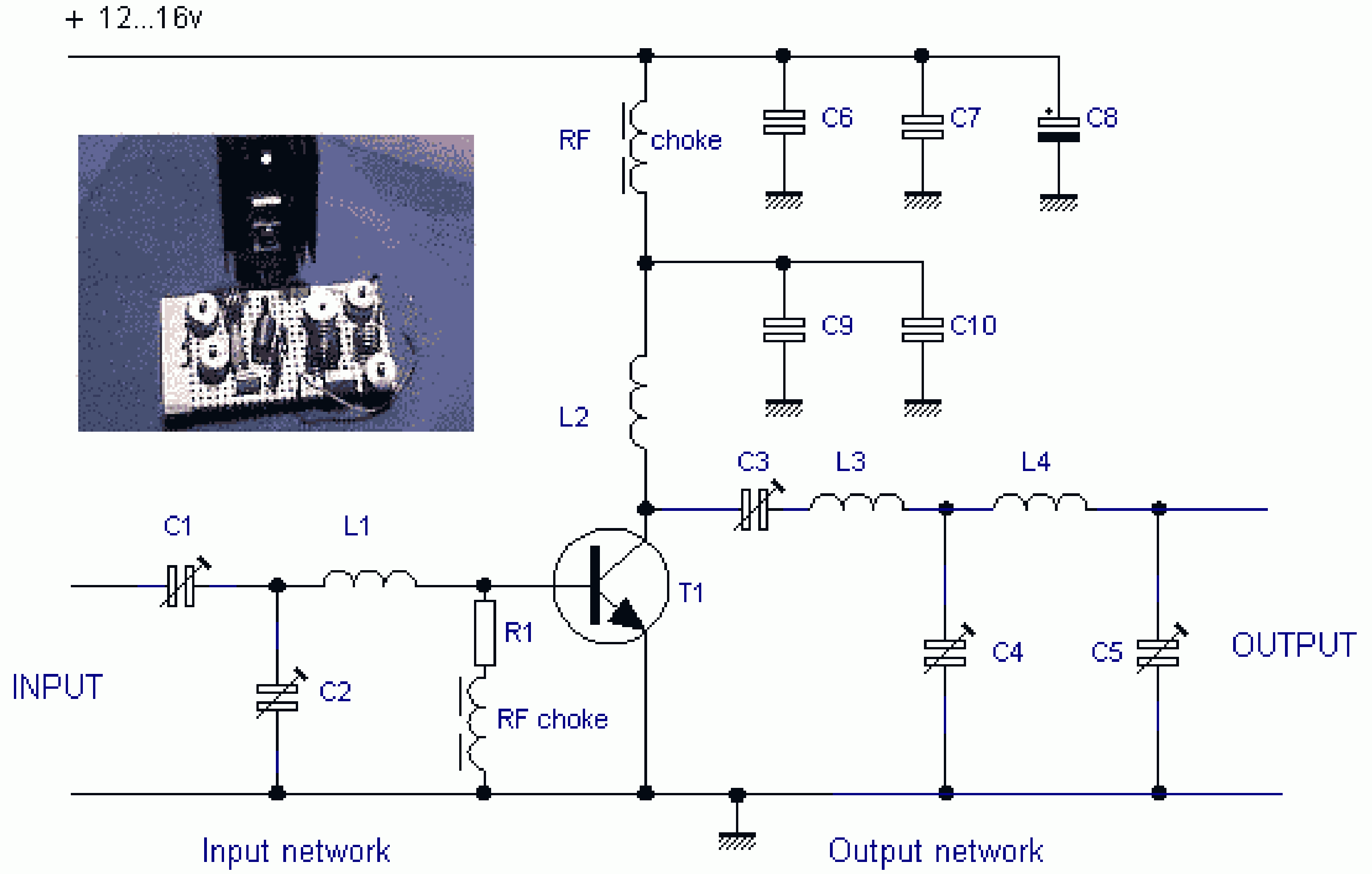
RE-PA6VHF6 Class C tuned VHF power amplifier for the 6-meter band,



T1 = 2sc1306,2sc3133, 2sc1969
L1 = 4 wnd 0.8 Ø8mm
L2 = 12 wnd 0.8 Ø6mm
L3 = 7 wnd 0.8 Ø9mm
L4 = 5 wnd 0.8 Ø7mm
C1, C2, C3 = 3...60pF
C4 = 3...120pF
C5 = 0...40pF
C6, C9 = 100nF
C7,C10 = 1nF
C8 = 22uF/25v tantal
R1 = 10

RF-shoke = 6t of 0.4mm wire throo a ferrite bead; Or 40t of 0.2mm over a 1Mohm 1/2watt resistor and solder the ends on the resitor connections.

Note: Max output power is easely 5watts, Hfe 4
Example: Input 0.5watt -> 2watt output at 13.8v
Input 1.5watt -> 6watt output at 13.8v

Notes: Tune C1 and C2 to match the used source impedance, then tune C3,C4 and C5 with on the output a 50 Ohm dummy load to maximum output power. Repeat this - if needed - until maximum output is reached.

Important: T1 must be cooled. To shield the amplifier build it in a alu or copper box!

wnd = turns

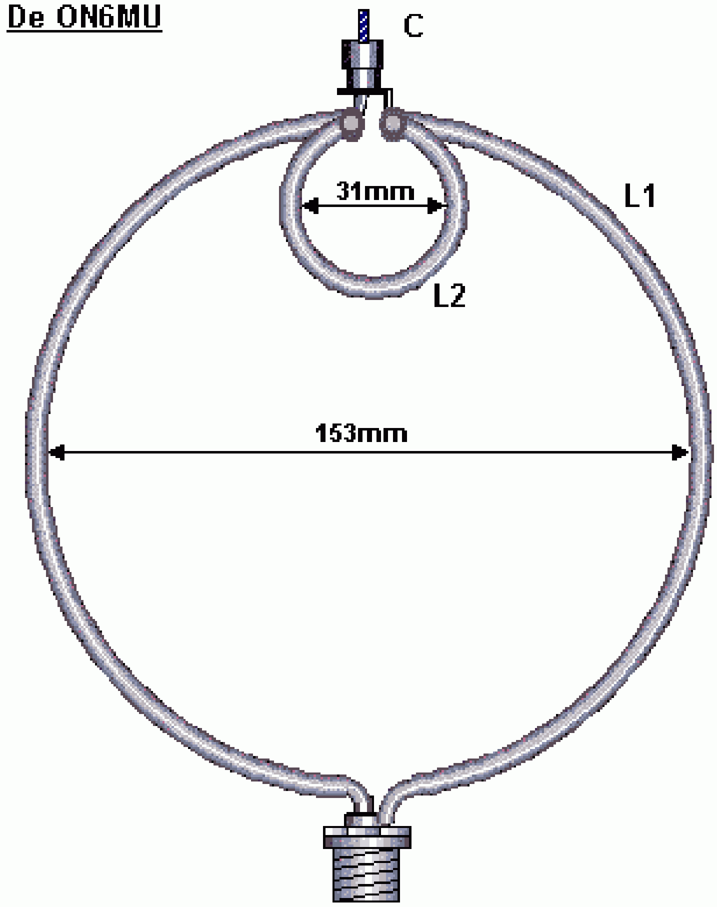
Ideal for AM/CW/FM modes

de ON6MU

www.qsl.net/on6mu

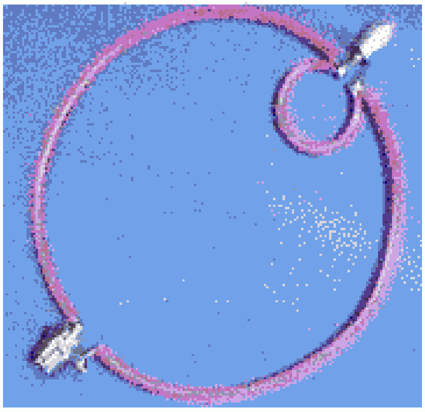
VHF Magnetic Loop RE-A144L14P

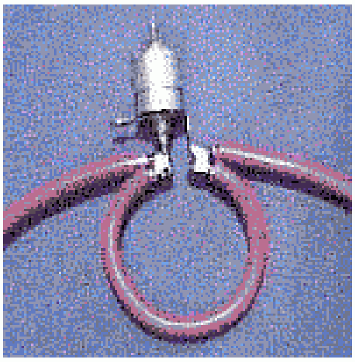
De ON6MU

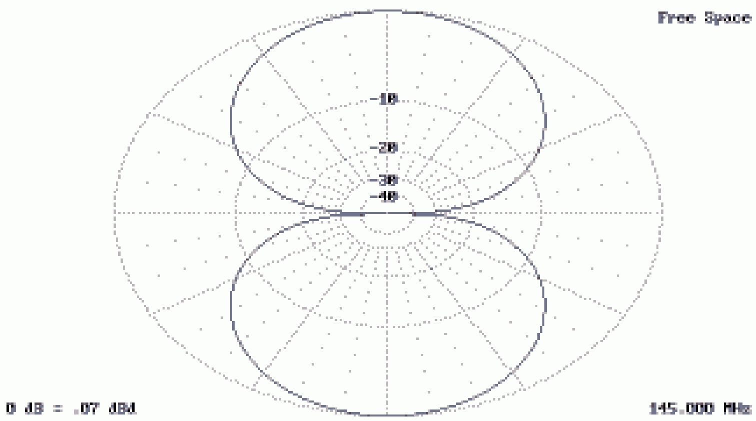


A magnetic loop has a very small bandwidth but unsensitive to man made noise. It is much smaller then a conventional antenna for the same frequency and has a gain that can be compared to a quarter wave antenna even if the loop is mounted a meter from the ground. All in theory ofcourse.
It has a bi-directional radiation pattern like a dipole and is very selective. This means that you need to tune the antenna using 'C' about every 0.5Mc on VHF for maximum reception and 1:1 SWR. Ideal for portable use or as a repeater antenna.
'C' has to be an air- or vacume capacitor because of the high voltages that can occure on the capacitor when transmitting!
I tested the antenna using my VHF portable in my garden and the loop had about the same results as my quarter wave mounted 6 meters higher. The 'Q' of the loop depends on the quality of the material, size and 'C'.

C = air- or vacume capacitor of 0...20pF
L1 = 1/4 wave: for 145MHz use a copper or brass wire with a length of 49cm and at least 3mm in diameter.
L2 = is 1/5 of the length of L1: for 145MHz use the same material as L1 and has a length of 9.5cm



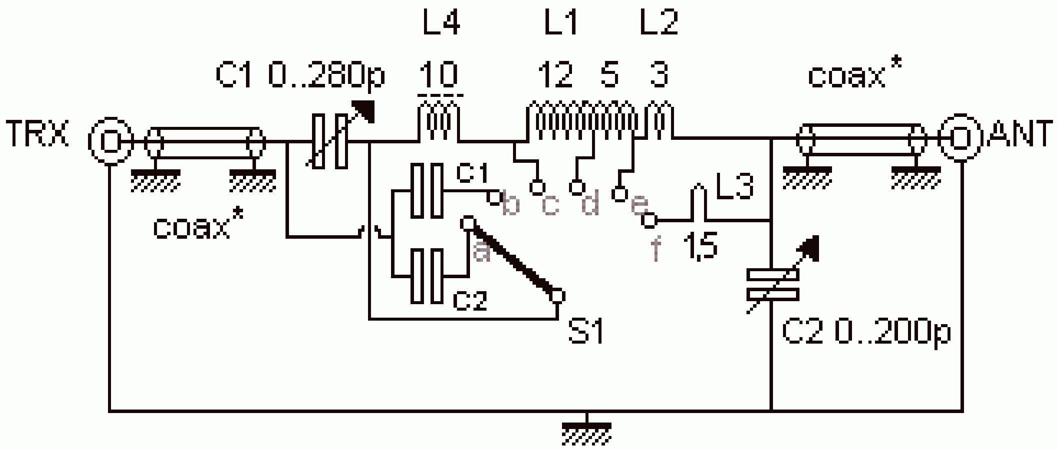




Note: maximum power depends on the capacitor used. In this example the maximum power is around 10watt
Tune 'C' very carefully until SWR is 1:1. A few pF over or under and you'll get a high SWR. Don't tune the capacitor while transmitting!
Can be tuned in any part of the entire VHF band.

http://www.qsl.net/on6mu

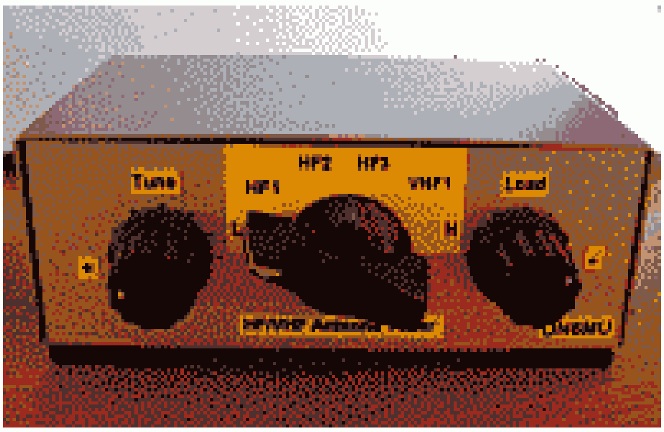
RE-AT3HF2   HF/VHF Mini Antenna Tuner de ON6MU Rev. 2



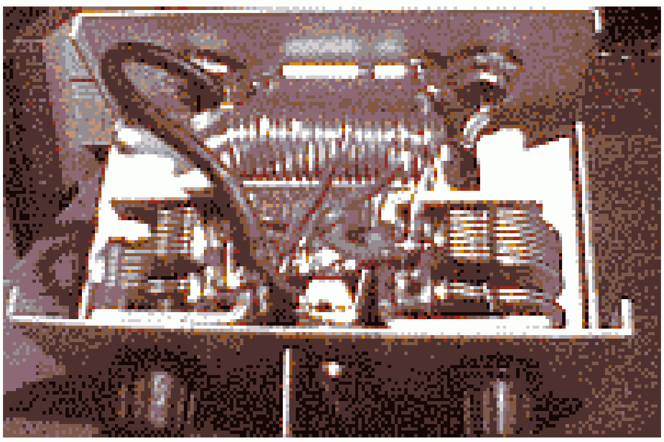
Switch posistion
a=Lowest
b=HF1
c=HF2
d=HF3
e=VHF1
f=Highest

Freq.range:3...150MHz
Power: 60watt AM/FM/CW
100watt SSB

2 x SO-239 chassis
RG-58 coax +- 6cm length (depending of the size of the box and feed the capacitor with the coax leeding from the SO-239 and ground it on both sides)
S1= 6-way switch
C1 and C2 = variable air capacitor (C1 is isolated from the ground!)
L1: 17 turns of 1,5mm diameter copper wire and 16 mm coil diameter (13mm inside)
0,5mm space between the turns, a tap at 12th turn
L2: 3 turns of 1,5mm diameter copper wire and 16 mm coil diameter, 2 mm spaced
L3: 1,5 turns of 0,9mm silver wire and 9mm coil diameter, 0,5mm spaced
L4: 10 turns of 1 mm diameter isolated copper wire winded close together, 12mm coil diameter
Core is a ferrite (like from an MG radio Ø 10mm) of 2 cm length
C1: 120pF 500volt,
C2: 470pF 500volt



Alu box: L120 x D75 x H45 mm



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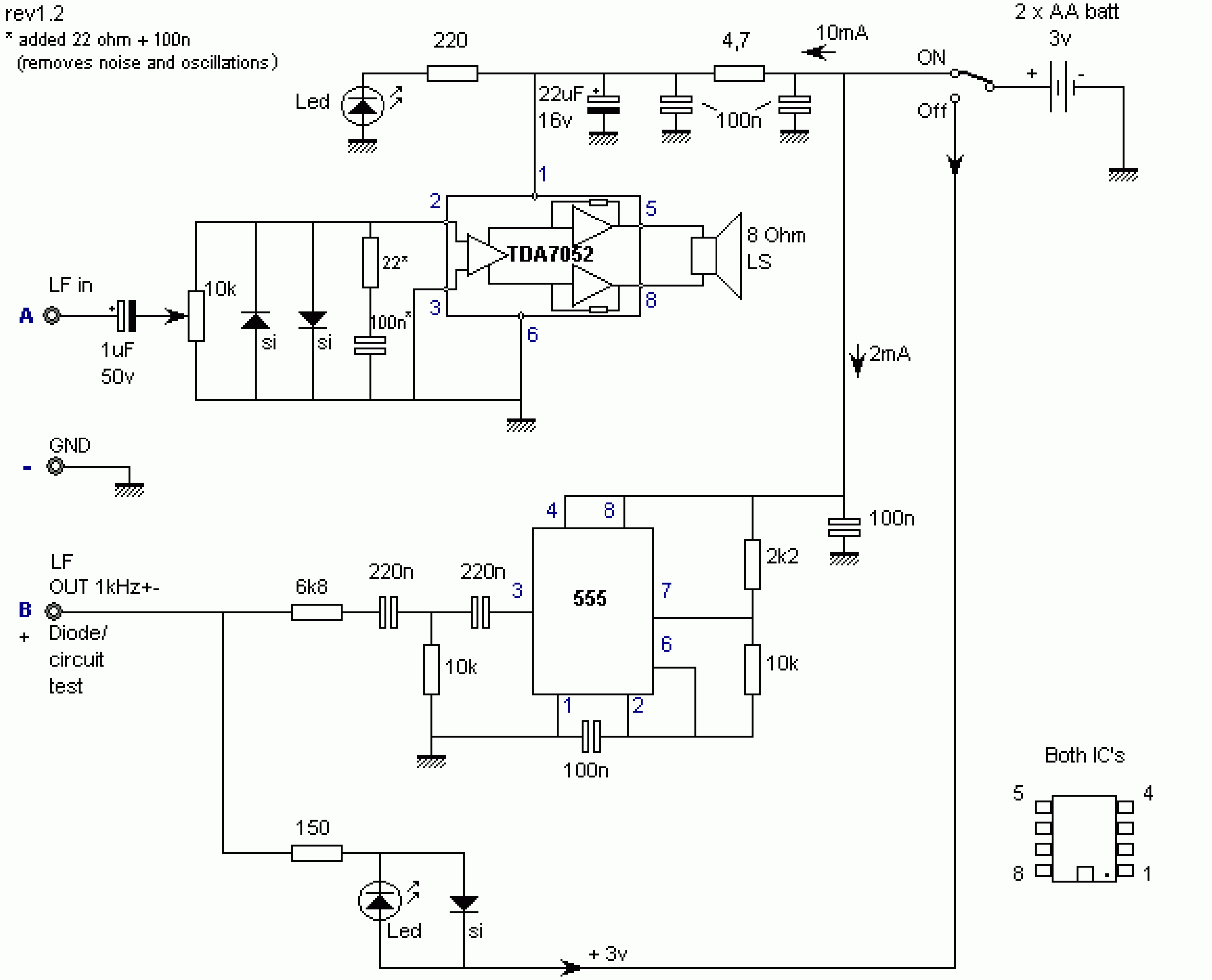
RE-M1LFT Audio-, Diode-, and Circuit Tester, By ON6MU



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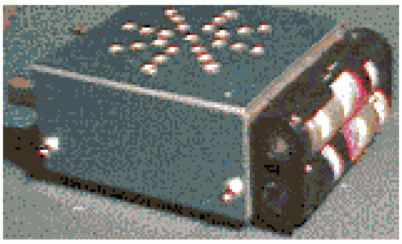
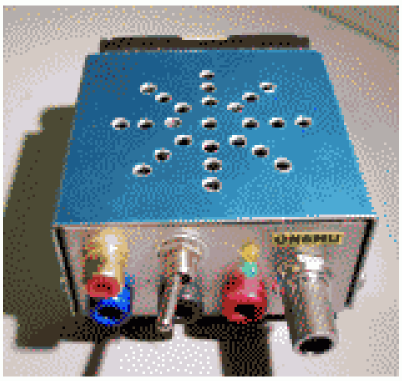
This very handy simple solid-state battery operated tester can be used for:
* to audit any LF/AF signal
* circuit tester and diode tester
* 1000Hz tone generator
When you switch S1 OFF the diode/circuit tester schematic can be used
Works on two 1.2...1.5volt AA-batteries.





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RE-ABU4HF Longwire Balun, de ON6MU

Fig 1

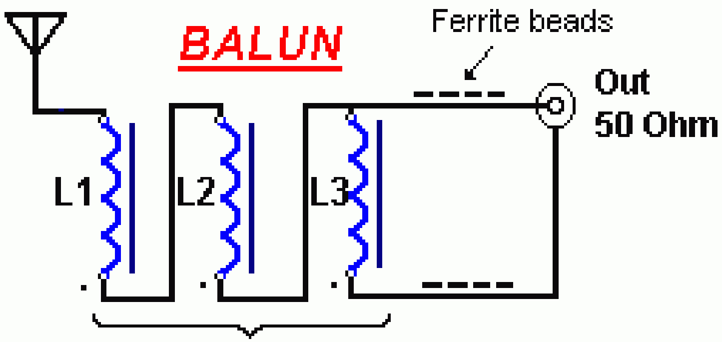
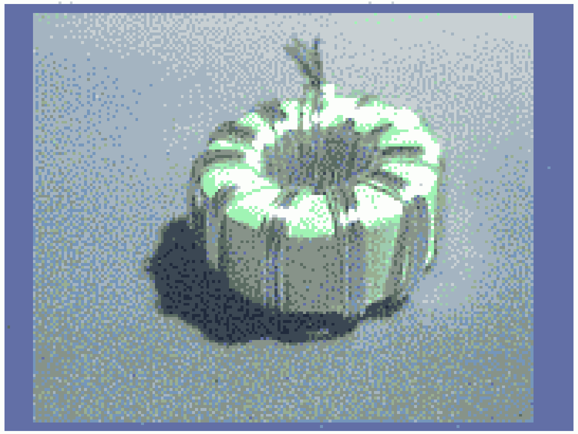


Fig 2



You need 3 isolated pieces of wire of about 0.8 mm in diameter and about 50 cm in length (depending on the size of your core).
Be sure that you cover the core evenly and that the wires are neatly close to each other (fig.2).
I needed about 60 cm wire (1mm) to be able to have 11 turns around the iron powder core.
Connect the wires as in fig. 1 (use a Ohm meter to find out L1, L2 and L3 or use 3 different colors for each wire).
Then connect PL-connector to L3 where you connect your coax (fig. 4) and connect the beginning of L1 to the bolt you are using to connect the longwire to and put everything in a waterproof box (fig. 5). Good DX-ing, de ON6MU

Note: You can add some ferrite beads placed over the coax, or turn some RG-58 coax over a ferrite bar +/- 10 turns to attenuate high frequency EMI/RFI electronic noise even further.

Fig 4

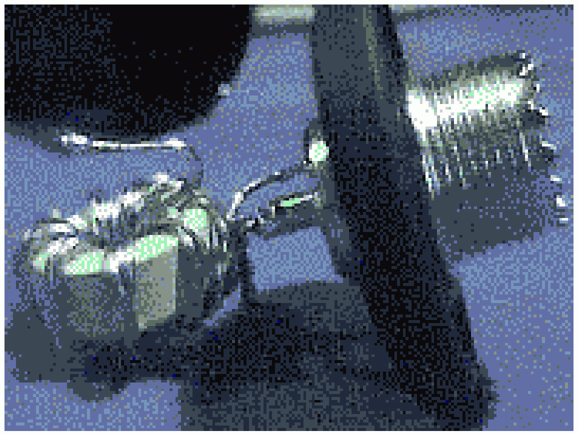


Fig 5

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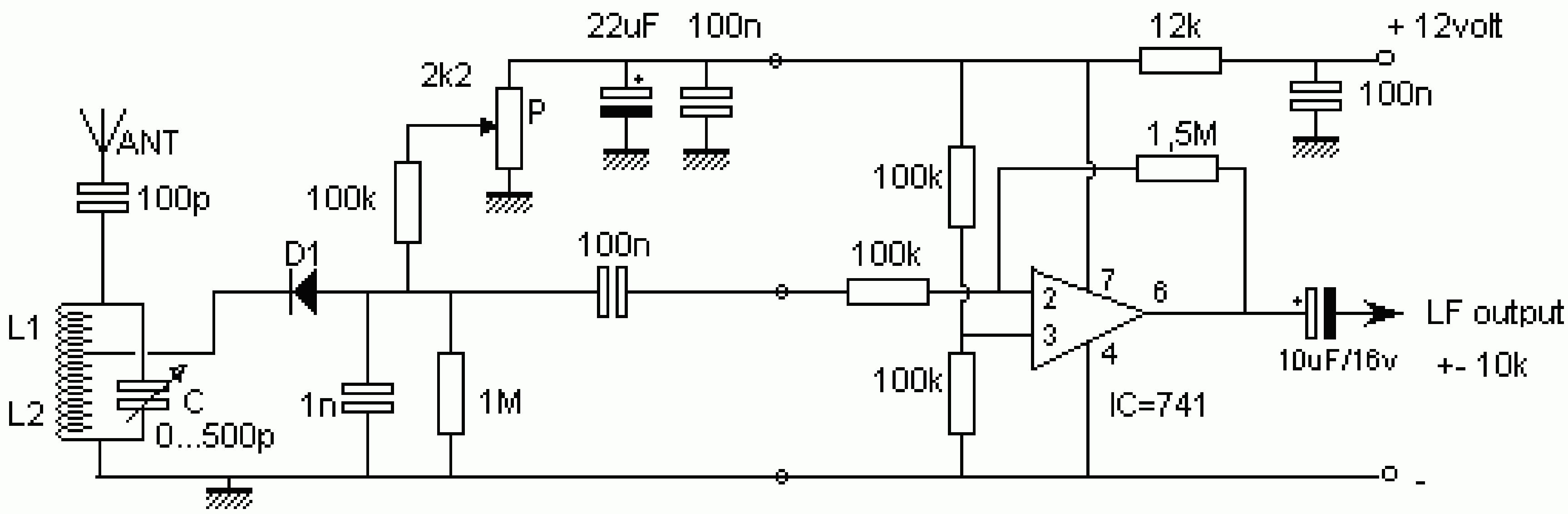
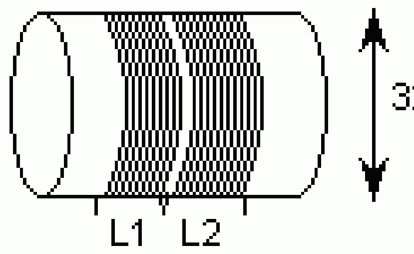
Enhanced crystal receiver, de ON6MU



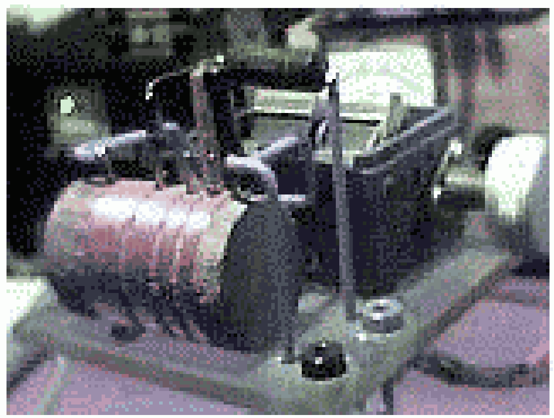
L1=40 wnd 0,2mm over 32mm
L2=50 wnd 0,2mm over 32mm
Frequency=500...1600KHz



D1=silicon diode 1n4151, 1n4448, 1n4001...

Tune P (2k2) till you get the best reception.

Note: you can experiment with
L1,L2 and C to receive other
frequency bands.



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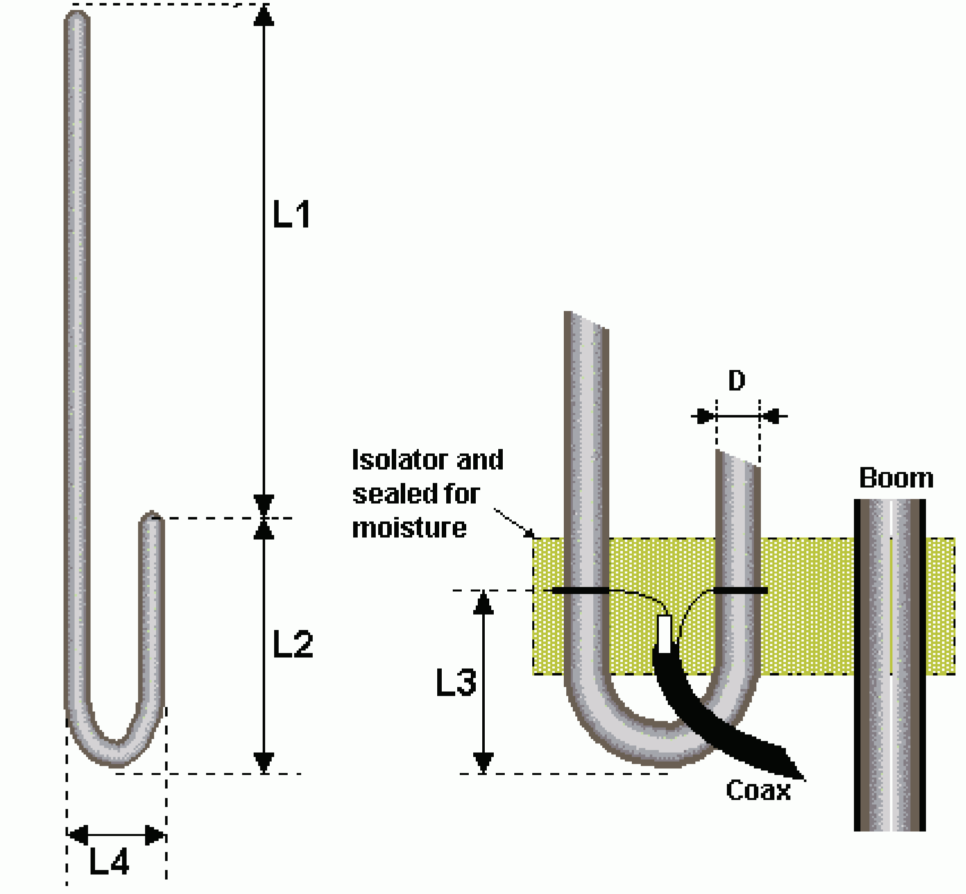
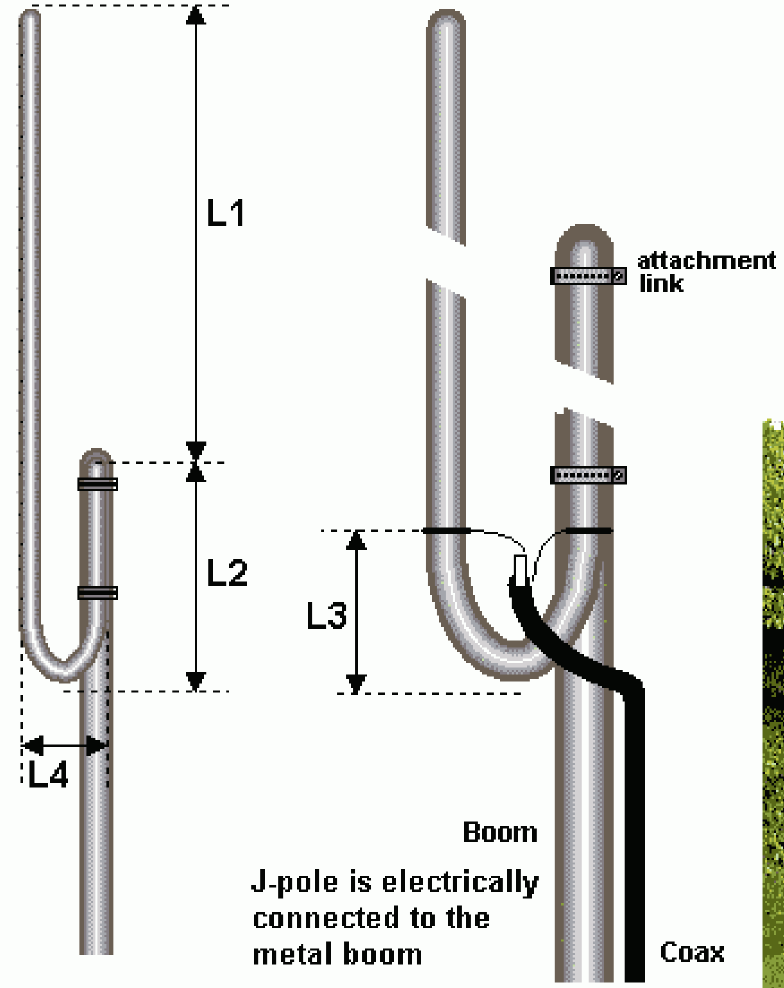
RE-A14430VJP VHF/UHF J-POLE Vertical Antenna, de ON6MU rev.2

Type 1
J-Pole isolated from the ground



Type 2
J-Pole grounded via boom

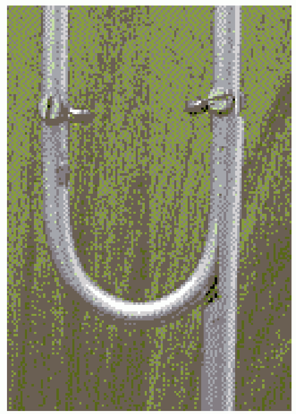


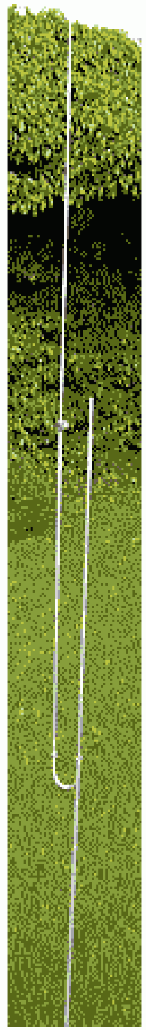
VHF	UHF	D
L1=985mm	L1=340mm	Aluminum or
L2=485mm	L2=160mm	copper tube of
L3=75mm	L3=30mm	8 of 10mm Ø
L4=80mm	L4=40mm	

Average gain is approx. 4dB
VHF frequency range 144...148 MHz
UHF frequency range 430...450 MHz

L1 = 1/2 wavelength - 5%
L2 = 1/4 wavelength - 5%
L4 = not critical and depends mostly on the tube diameter. The distance between them is around L4= D x 4

Note: SWR can be adjusted by adjusting the the connectionpoint L3 higher or lower.
The measurements are not to critical and the material and diameter used for the tubes can vary and so the point of connecting the coax can vary to.





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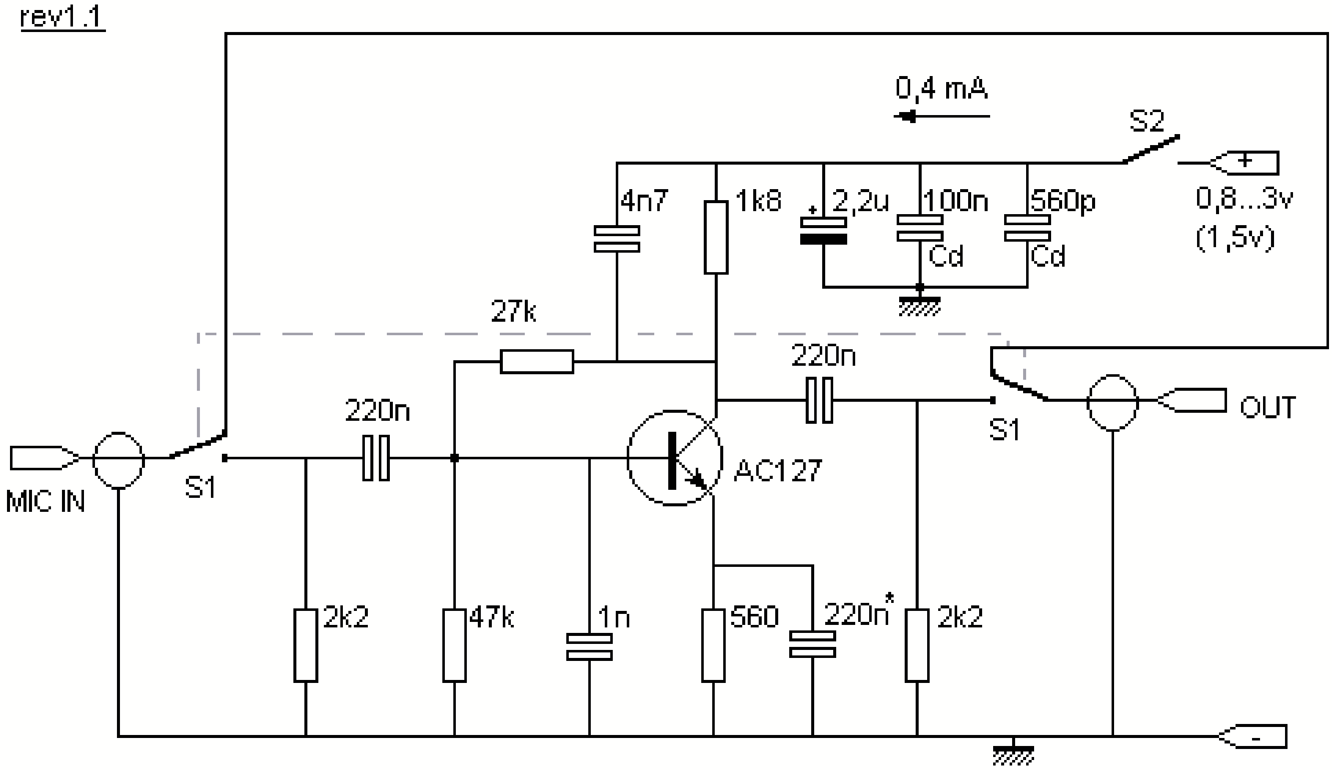
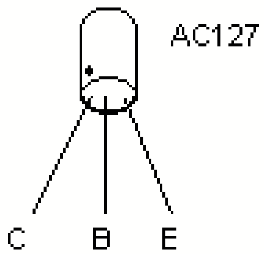
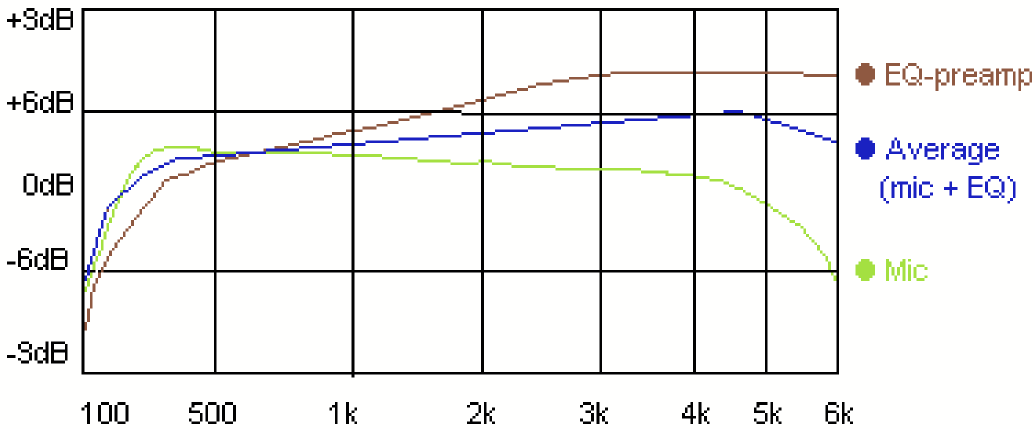
RE-LFA2EQ EQ - LF Pre-amplifier *(with high frequency improvement)* high-emphasis

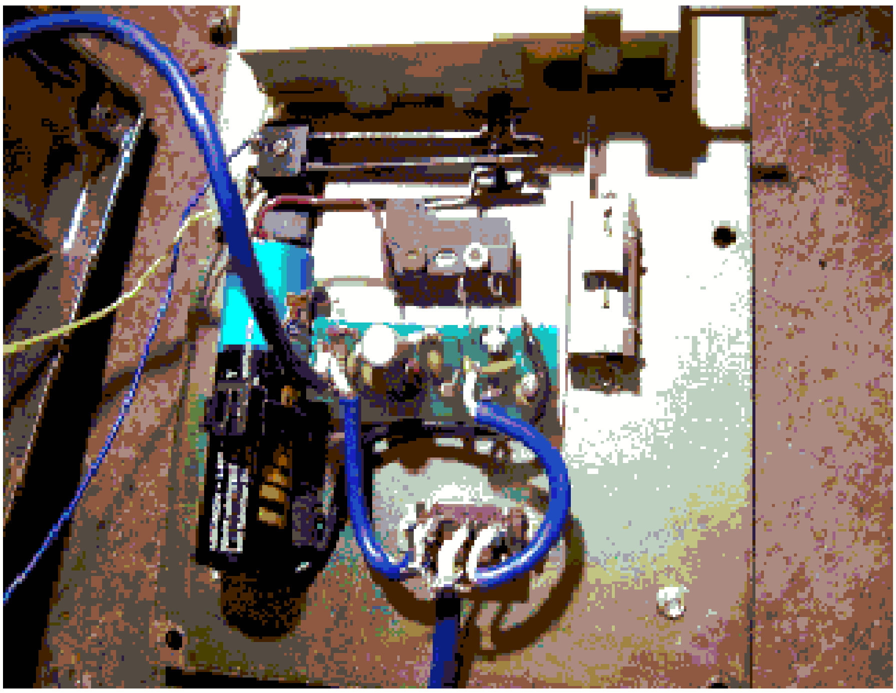
rev1.1







By ON6MU



Vcc: 0,8...3v (works perfect with 1,5v AA battery)

I: 40 uA

Hfe: 5dB @ 1kHz

S1: switch between pre-amp and direct mic connection

S2: Activates when pressing PTT to supply voltage to pre-amp

C 220nF: ensures high frequency amplification. Can be replaced by a 10uF capacitor for normal pre-amp usage (Hfe 10dB)

All capacitors are polystyrene, except Cd

S2 needs to be placed in such a manner that is closes before the PTT switch closes hence preventing plops or clicks.

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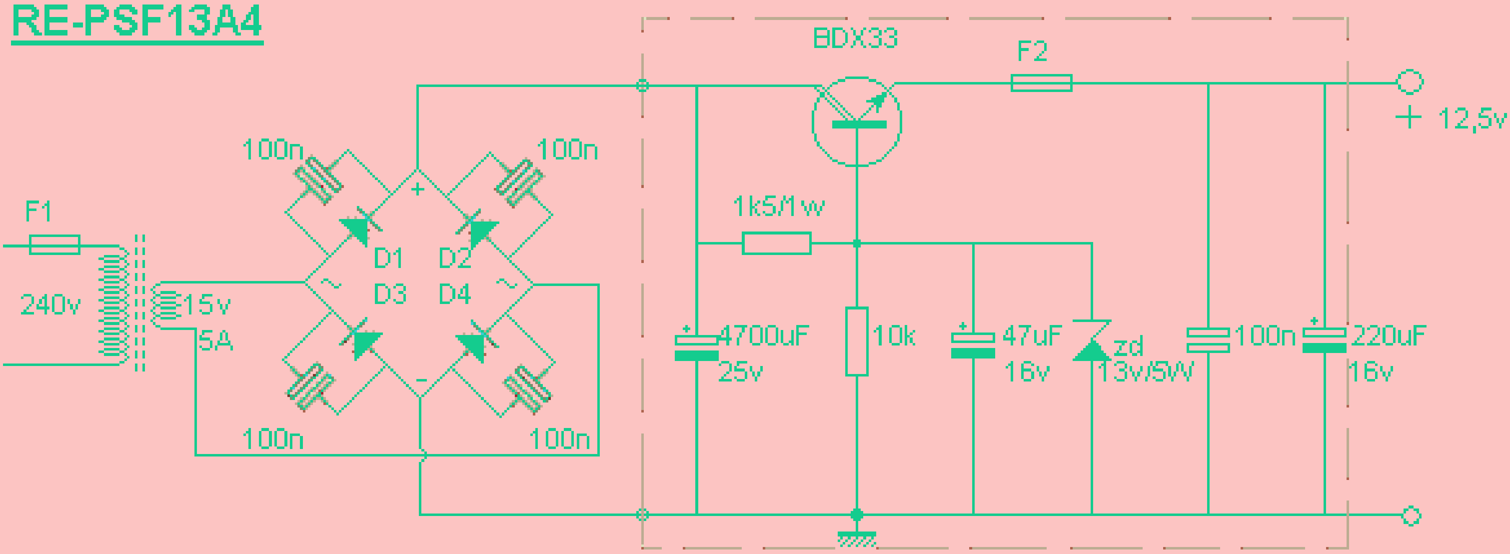
4 Amp one transistor power supply, de ON6MU
RE-PSF13A4



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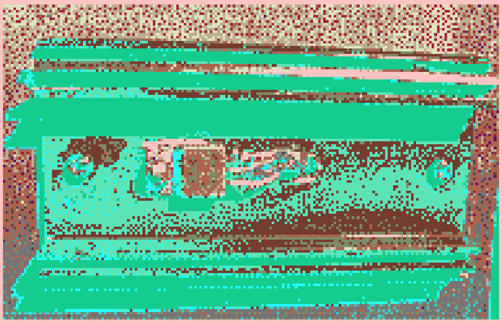
This one-transistor power supply uses a BDX33 (TO220 Darlington NPN transistor) therefor no extra driver transistor is needed. You can use this power supply for low power applications or for applications that can use up to 5Amps continues. Remember to cool the transistor properly!

Change Zd for other voltages.



D1...D4 = 1..2Amps use 1N4007
5 Amps use
or equivalents
Transfo= 1..2Amps or 5Amps 15volts (18v max)
F1 = 0,5A (1..2Amps)
1A (5Amps)
F2 = 2A (or 6A)

I made myself a "Retro Sound-Box" using a very old car radio, a 20cm speaker (woofer), a 7cm tweeter and an telescopic antenna. I used the above power supply which has enough amps to feed the old 8 Watt car radio. Everything build in a wooden box 30x22x17cm. The BDX33 is mounted on the backside of the case.